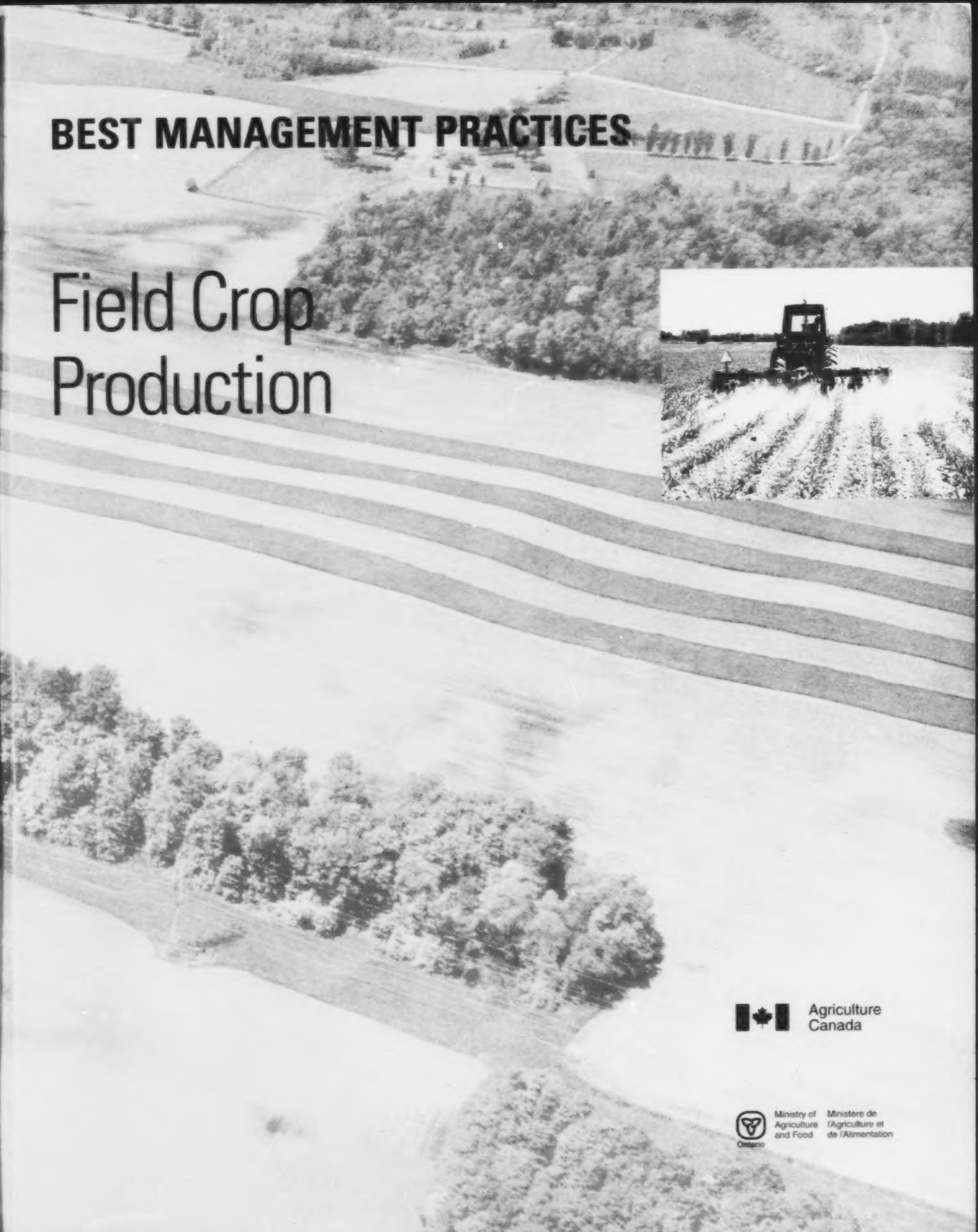

BEST MANAGEMENT PRACTICES

Field Crop Production

Agriculture
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Ontario
Ministry of Agriculture and Food
Ministère de l'Agriculture et de l'Alimentation

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Achieving environmental objectives in an increasingly competitive business climate requires access to the best and most up-to-date information available. The BEST MANAGEMENT PRACTICES referred to in this booklet are practical guidelines drawn from research and on-farm experience. We have attempted to provide these practices in the most up-to-date and accurate manner possible. The information is as neutral and unbiased as possible so that farmers may select options that fit their own environmental and business objectives.

Each booklet contains: an introduction to the subject matter, a discussion of management and environmental concerns, a list of available options, practical how-to tips, and references to more detailed information.

To assist you in locating information, each booklet includes a guide relating commonly-held business and environmental goals to information provided in the Best Management Practices manual. For more detailed information, check the table of contents in each booklet and the references mentioned at the end.

The Best Management Practices Manual includes five booklets. You may want some or all of them.

BOOKLET 1	Best Management Practices - A First Look - Practical Solutions for Soil and Water Problems.
BOOKLET 2.	Best Management Practices - Livestock and Poultry Waste Management.
BOOKLET 3.	Best Management Practices - Field Crop Production.
BOOKLET 4.	Best Management Practices - Horticultural Crops.
BOOKLET 5.	Best Management Practices - Farm Forestry and Habitat Management.

Planning for Change

Effective planning calls for the systematic consideration of three key factors: production goals, financial implications, and environmental impact. Nothing less than this comprehensive approach will allow farmers to enhance the environment while meeting business objectives.

Farm planning highlights opportunities for pursuing business and environmental objectives at the same time. Planning also shows what trade-offs might be effective when business and environmental objectives compete. Best management practices are an essential part of developing a sustainable farm plan. This manual will provide a ready-reference guide for environmental and conservation farm planning.

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Where to Find the Answers

Key

BOOKLET 2:
▶ Livestock and Poultry Waste Management

BOOKLET 3:
▶ Field Crop Production

BOOKLET 4:
▶ Horticultural Crops

BOOKLET 5:
▶ Farm Forestry and Habitat Management

Save Money

REDUCE FERTILIZER INPUTS:
- ▶ ▶ Nutrient Management
- ▶ Manure Handling and Storage
- ▶ ▶ Manure Application Systems
- ▶ ▶ Cover Crops and Rotation
- ▶ ▶ ▶ ▶ Soil Erosion Control (see Save the Soil)

REDUCE PESTICIDE INPUTS:
- ▶ ▶ Pest management

ELIMINATE REPLANTING:
- ▶ ▶ ▶ ▶ Control Soil Erosion (see Save the Soil)

REDUCE ENERGY INPUT:
- ▶ ▶ Tillage Options
- ▶ Windbreaks and Shelterbelts
- ▶ Woodlot Management

REDUCE BUILDING MATERIAL COST:
- ▶ Woodlot and Plantation Management

BETTER TIME MANAGEMENT:
- ▶ ▶ Tillage Options
- ▶ Manure Handling and Storage
- ▶ ▶ Manure Application Systems
- ▶ ▶ Crop Rotation
- ▶ Woodlot Management

INCREASED YIELDS:
- ▶ ▶ Tillage Options
- ▶ ▶ Rotation
- ▶ ▶ ▶ ▶ Soil Erosion Control (see Save the Soil)
- ▶ Windbreaks and Shelterbelts
- ▶ ▶ ▶ Improve Soil Structure

Save the Soil

WATER EROSION CONTROL:
- ▶ ▶ Cover Crops and Crop Rotation
- ▶ Erosion Control Structures.
- ▶ ▶ Tile Drainage
- ▶ Strip Cropping
- ▶ ▶ Buffer Strips
- ▶ Contouring
- ▶ Grass Headlands
- ▶ ▶ Tillage Options
- ▶ Intercropping
- ▶ Fragile Land Retirement

IMPROVE SOIL STRUCTURE AND REDUCE COMPACTION:
- ▶ ▶ Cover Crops and Crop Rotation
- ▶ ▶ Tile Drainage
- ▶ Grass Headlands
- ▶ ▶ Tillage Options
- ▶ ▶ Proper Application of Livestock Manures

WIND EROSION CONTROL:
- ▶ Tree Windbreaks and Natural Fencerows
- ▶ Vegetative Wind Barriers
- ▶ ▶ Cover Crops
- ▶ ▶ Tillage Options
- ▶ ▶ Strip Cropping

FRAGILE LAND RETIREMENT:
- ▶ Reforestation
- ▶ ▶ Buffer Strips
- ▶ Fencing to Prevent Livestock Access to Streams
- ▶ Wildlife Habitat Plantings

STREAMBANK PROTECTION:
- ▶ ▶ Buffer Strips
- ▶ Tile Outlet Protection
- ▶ Rock Protection on Banks
- ▶ Wildlife Habitat
- ▶ Low-flow Livestock and Machinery Stream Crossing

RELIEVING TILLAGE TRANSLOCATION:
- ▶ Reforestation and Intercropping
- ▶ ▶ Tillage Options
- ▶ ▶ Cover Crops and Crop Rotations
- ▶ Contouring
- ▶ Strip Cropping

Save the Water

CONTROLLING NITRATE LEVELS:
- ▶ Manure Handling and Storage
- ▶ ▶ Manure Application Systems
- ▶ Milkhouse Waste Storage and Treatment Systems
- ▶ ▶ Nutrient Management
- ▶ ▶ Cover Crops and Crop Rotations

CONTROLLING PHOSPHATE LEVELS:
- ▶ Manure Handling and Storage
- ▶ ▶ Manure Application Systems
- ▶ Milkhouse Waste Storage and Treatment Systems
- ▶ ▶ Nutrient Management
- ▶ ▶ ▶ ▶ Soil Erosion Control (see Save the Soil)

REDUCE SEDIMENT LOSS:
- ▶ ▶ ▶ ▶ Soil Erosion Control (see Save the Soil)

REDUCE BACTERIA LEVELS:
- ▶ Manure Handling and Storage
- ▶ ▶ Manure Application Systems
- ▶ Milkhouse Waste Storage and Treatment Systems
- ▶ Fencing to Prevent Livestock Access to Streams
- ▶ Low-flow Livestock Stream Crossing

PROPER PESTICIDE MANAGEMENT:
- ▶ ▶ Pest Management
- ▶ ▶ ▶ ▶ Soil Erosion Control (see Save the Soil)-for Pesticides Attached to Soil

ADEQUATE WATER SUPPLY:
- ▶ ▶ Tile Drainage
- ▶ Irrigation and Water Table Management
- ▶ ▶ Water Conservation-Residue Management
- ▶ Water Conservation-Maintaining Trees

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FIELD CROP PRODUCTION

INTRODUCTION

Producing high yields has always been an important part of farming. When input costs were low compared to crop returns, the best way to farm was to fertilize for maximum yields and then, add a little extra. The feeling was that you could lose more with too little input than with too much.

With the costs of fertilizer, fuel and other inputs increasing and crop prices not keeping pace, the emphasis has changed. Inputs are carefully measured so that the yield from each unit is worth more than the cost of the input. The greatest yields do not necessarily give the greatest profit.

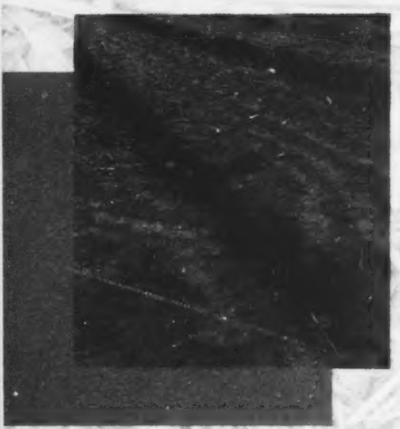
In recent years, the focus has widened to include environmental factors in the crop production equation. It is no longer acceptable to ignore what happens beyond the fence because of the way we farm.

Best management practices are tools for meeting today's agricultural goals. To be a best management practice, an action must maintain or increase crop returns while minimizing the impact on the environment. There is no one system for all farms. The combination of practices appropriate for your farm will depend on individual problems and opportunities.

The first part of this booklet will help you understand the basics such as soil management, residue management, crop rotation, pest management, nutrient management as well as the importance of using a systematic approach to change. The next three sections focus on different types of tillage: conventional tillage, mulch tillage and no-till/ridge tillage. And finally, the booklet provides some non-tillage options that improve the environment.

The booklet cannot provide you with all the possible information. Rather, it gives you the basics and provides references for further reading.

Some terms used in this booklet may be unfamiliar. To avoid confusion, we are using the following definitions for the different types of tillage:



Conventional tillage leaves less than 30% residue.

Mulch tillage leaves more than 30% residue.

Conventional tillage is any system which attempts to cover most of the residue, leaving less than 30% of the soil surface covered with residue (or crop remains) after planting. Usually, the moldboard plow is used along with a variety of other tillage tools.

Mulch tillage is any system where soil is disturbed between harvesting one crop and planting the next. However, in this case, more than 30% of the soil surface is left covered with residue after planting. Chisel plows, offset discs or modified moldboard plows are the common implements. Other terms that you may hear to describe this system are reduced tillage, minimum till or conservation tillage.

No-till is any system where the soil is not disturbed between harvesting one crop and planting the next. Some tillage may be done by attachments to planting equipment to assist seed and fertilizer placement.

Ridge tillage is a specific form of no-till where crops are planted on pre-formed ridges. Inter-row cultivation is done after the crop has emerged in order to control weeds and re-form the ridges.

You may wish to change your cropping system for many different reasons such as: to save money, to increase yields, to save labour, to solve erosion problems, or to reduce pesticide use. Whatever the reason, the first stage of change is to assess where you are now and what your goals are. Once you have done that, this booklet should help outline some of the options available. Good luck!

No-till is any system where the soil is not disturbed between harvesting one crop and planting the next.

REASONS TO CONSIDER CHANGING YOUR SYSTEM

On-Farm Concerns

Soil loss by erosion creates an economic loss because it removes the most productive layer of soil first and exposes less productive layers. Lower layers have less organic matter and fewer available nutrients. Therefore, yield potential will drop. Eroded soil will require large amounts of fertilizer to improve fertility and will be harder to manage because of poor soil structure due to low levels of organic matter. Soil loss is a waste of a basic resource which affects the farm's future productivity.

See the section on Non-Tillage Options for more information.

Ridge till is a system where crops are planted on pre-formed ridges.

Yield is affected by many factors: soil productivity, soil type, drainage, weather, crop genetics and farm management. The best way to improve yields may vary from field to field and even, within one field. When making a decision on a tillage system, remember:

- ►Lower yields may not always mean lower profits. Different amounts of time, equipment costs, input and management go into different systems.
- ►Research comparing corn yields under different tillage systems shows the following (see table). These results could vary with different crops and different management.

CORN YIELD INDEX

	MULCH TILL	NO-TILL
[illegible]	98	105
[illegible]	99	97
[illegible]	96	104
[illegible]	92	94

Five Year Average (Moldboard = 100)
From 1991 Tillage 2000 Report.

Farm input costs such as labour, fuel, and machinery decrease as tillage decreases. Reducing inputs saves money and resources. Planting a crop with fewer trips across the field increases productivity and allows more timely planting.

Herbicide use may increase in the short-term with decreased tillage as a result of using herbicide for spring weed burnoff to replace weed control by tillage.

Problem weed species also change as tillage changes. This may cause you to modify the herbicide program. Eventually, though, careful management will reduce the need for herbicides. In a ridge till system, banding herbicides will reduce application rates by one-half to two-thirds.

Reducing the number of field passes for planting reduces labour needs. No-till and ridge till systems reduce labour by as much as one-third to one-half from conventional tillage. Chisel plowing requires 25% less labour than moldboard plowing.

In the long-term, reduced tillage reduces capital costs. As tillage decreases, the need for large equipment also decreases. In a no-till or ridge till system, the largest tractor required will be the one used to pull the planter (or grain buggy). Most farmers keep their plows when they move to a new system until the system proves itself. Eventually, farmers will be able to sell equipment that is no longer needed. A good opportunity to make changes comes when an old plow needs replacement. Use the money that would have gone into buying a new plow for alternate tillage equipment.

"Renting or borrowing of equipment lets you look before you leap."

Equipment needed for tillage systems:

- ▶Machinery inventory for conventional tillage includes the moldboard plow, disc, harrow and field cultivator.
- ▶Switching to mulch tillage will require the purchase of a chisel plow or offset disc. Higher residue levels may require modification to cultivation and planting equipment. For example, trash whippers may be needed to clear residue ahead of planter units.
- ▶Switching from mulch till to no-till requires the purchase of residue coulters and trash whippers for the planter, a heavier frame for strength and weight, and springs for more downward pressure. It may also require purchase of a new planter or drill.
- ▶Starting into ridge tillage requires planter attachments to clean the ridge top. Guide wheels or automatic guidance systems keep the planter on the ridge. Special inter-row cultivators are used between the ridges during the growing season. To keep traffic off the ridge, wheel spacing must be adjusted for all equipment.

Energy use declines with a reduction in tillage. See the table below for more detail.

[illegible]

OPERATION	TILLAGE SYSTEM (NUMBERS SHOW LITRES OF DIESEL FUEL/HECTARE)			
	CONVENTIONAL	*CHISEL PLOW*	*DISC*	*NO-TILL*
MOLDBOARD PLOW	[illegible]	–	–	–
CHISEL PLOW	[illegible]	11	–	–
DISC	[illegible]	6	6	–
[illegible]	[illegible]	6	6	–
[illegible]	[illegible]	1	1	1
PLANT	[illegible]	4	4	5
[illegible]	[illegible]	4	4	–
[illegible]	[illegible]	15	12	6
TOTAL	[illegible]	47	33	12

Yield is affected by many factors: soil productivity, soil type, drainage, weather, crop genetics and farm management. The best way to improve yields may vary from field to field and even, within one field. When making a decision on a tillage system, remember:

- ► Lower yields may not always mean lower profits. Different amounts of time, equipment costs, input and management go into different systems.
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CORN YIELD INDEX

SOIL TYPE	MULCH TILL	NO-TILL
SAND	98	105
LOAM	99	97
CLAY LOAM	96	104
CLAY	92	94

Five Year Average (Moldboard = 100)
From 1991 Tillage 2000 Report.

Farm input costs such as labour, fuel, and machinery decrease as tillage decreases. Reducing inputs saves money and resources. Planting a crop with fewer trips across the field increases productivity and allows more timely planting.

Herbicide use may increase in the short-term with decreased tillage as a result of using herbicide for spring weed burnoff to replace weed control by tillage.

Problem weed species also change as tillage changes. This may cause you to modify the herbicide program. Eventually, though, careful management will reduce the need for herbicides. In a ridge till system, banding herbicides will reduce application rates by one-half to two-thirds.

Reducing the number of field passes for planting reduces labour needs. No-till and ridge till systems reduce labour by as much as one-third to one-half from conventional tillage. Chisel plowing requires 25% less labour than moldboard plowing.

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"Renting or borrowing of equipment lets you look before you leap."

required will be the one used to pull the planter (or grain buggy). Most farmers keep their plows when they move to a new system until the system proves itself. Eventually farmers will be able to sell equipment that is no longer needed. A good opportunity to make changes comes when an old plow needs replacement. Use the money that would have gone into buying a new plow for alternative tillage equipment.

Equipment needed for tillage systems:

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Energy use declines with a reduction in tillage. See the table below for more detail.

ENERGY REQUIREMENTS FOR DIFFERENT TILLAGE SYSTEMS

OPERATION	TILLAGE SYSTEM (NUMBERS SHOW LITRES OF DIESEL FUEL/HECTARE)			
	CONVENTIONAL	*CHISEL PLOW*	*DISC*	*NO-TILL*
MOLDBOARD PLOW	17	–	–	
CHISEL PLOW	–	11	–	
DISC	6	6	6	
INCORPORATING HERBICIDES	6	6	6	
SPRAY HERBICIDES	1	1	1	1
PLANT	4	4	4	5
CULTIVATE (EACH TIME)	4	4	4	
MACHINERY AND REPAIR	17	15	12	6
TOTAL	**56**	**47**	33	12

OFF-FARM CONCERNS

Sediment

Sediment, or eroded soil, deposited in Ontario waterways is a burden to all. Financially, it increases the costs of maintaining drains and shipping channels. Environmentally, sediment can destroy fish habitat and spoil recreational waters.

Sediment also contains soil nutrients and during spraying season, pesticide residues which can contaminate surface water. When sediment collects in one spot, at the bottom of a slope, for example, concentrated levels of pesticides may be toxic to crops.

Tillage systems that reduce soil erosion decrease sediment. Also see the section on Non-Tillage Options for more information.

Nutrients

Plant nutrients can be lost from any soil if nutrient application rates are too high. Nitrogen may be lost by leaching, which contaminates groundwater. Phosphates and potassium may be lost into surface water with eroded soil. Excess phosphates are a particular concern in watercourses.

Tillage systems which leave a lot of residue on the soil surface, reduce loss of nutrients by soil erosion. Residue also reduces run-off.

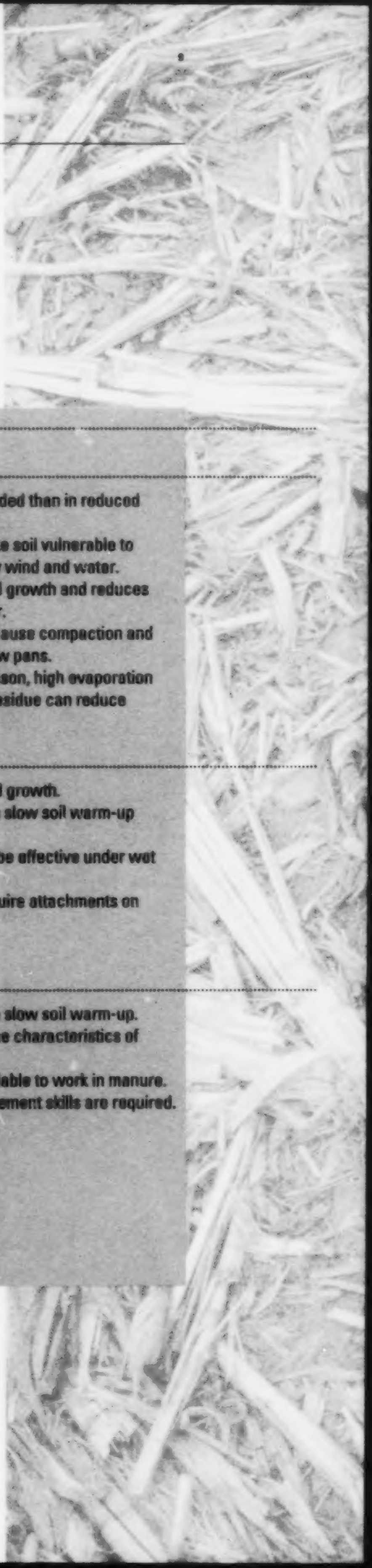
Nitrate loss is affected by adding more nitrogen (in the form of manure, fertilizer or legume residues) than crops require.

Soil moving off the farm in run-off can carry nutrients and pesticides into watercourses.

Pesticides

Pesticides can contaminate water because of the following: spray drift, spills near wells or streams, or improper disposal. However, entry into the water system may also result from surface run-off or leaching to tile drains and groundwater from farm operations.

Studies of major watersheds in Ontario have shown that few pesticides are found in rivers. However, traces of some are found during spraying season while others, such as atrazine, appear year-round. The most effective ways to control pesticide loss are by managing the soil to reduce run-off, improving handling to reduce spills, proper sprayer calibration and using recommended rates.



ADVANTAGES AND DISADVANTAGES OF TILLAGE SYSTEMS

	ADVANTAGES	DISADVANTAGES
CONVENTIONAL TILLAGE	• Familiar to most farmers and machinery widely available. • Incorporates manure without specialized equipment. • Soil warms faster in the spring than with less tillage. • Allows maximum frost action on soil. This breaks the soil into smaller clumps. • Low levels of surface residue permit high levels of water evaporation. This allows earlier planting and is a plus for poorly-drained soils.	• More equipment is needed than in reduced tillage systems. • Low residue levels make soil vulnerable to crusting and erosion by wind and water. • Tillage stimulates weed growth and reduces levels of organic matter. • Working wet soil may cause compaction and the development of plow pans. • During the growing season, high evaporation resulting from lack of residue can reduce crop yields.
MULCH TILLAGE	• Most of the same advantages as conventional tillage. • Residue left on soil surface reduces erosion and water run-off. • Labour inputs are lower than in conventional tillage. • Fewer trips over the field reduce costs. • Management skill levels required similar to conventional tillage.	• Tillage stimulates weed growth. • High residue levels can slow soil warm-up in the spring. • Primary tillage will not be effective under wet soil conditions. • High residue levels require attachments on the planter.
NO-TILL/RIDGE TILLAGE	• Lower input and capital expenses. • Labour inputs per acre are greatly reduced. • More organic matter is located near the surface, which improves soil structure. • High levels of residue drastically reduce soil erosion. • Increased biological activity in soil, which improves structure and increases the speed of pesticide breakdown.	• High residue levels can slow soil warm-up. • Success depends on the characteristics of the soil. • Fewer options are available to work in manure. • Above-average management skills are required.

ADVANTAGES AND DISADVANTAGES OF TILLAGE SYSTEMS

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LEARNING COSTS

Learning costs result from inexperience with a tillage system. Making poor decisions or failing to perform a task necessary to the system's success are examples. Mistakes can be costly because they affect time requirements or yield. Research a system carefully before implementing it. It may take a little extra time at the beginning, but will help you avoid errors.

Experience has shown that it is wise to start small and expand a new system as success allows. As one expert says, "A big mistake on a small area is a small mistake, but a small mistake on a large area is a big mistake."

Examples of learning costs:

- Trying to plant on the ridge without guide wheels. On the day you want to plant, it is too late to find out that the planter won't stay on the ridge.
- Trying to plant no-till into heavy corn residue and finding that heavy-duty coulters are needed.
- Having to till a field an extra time to remove ridges and lumps left by poor moldboard plowing.

Before selecting a tillage system, ask yourself the following questions:

- Will it work for my cropping and livestock system?
- Are other erosion control measures necessary?
- Is it suitable for my soil?
- Does it address the on and off-farm concerns in my area?
- Can I afford to make the necessary changes and buy the equipment?
- Do I have the management skills to make the system work?
- Can I get training, advice and information to improve my skills?
- Is there someone I can talk to whom has adopted the system successfully?

With proper preparation and consideration, farmers can adopt best management systems for their farm.

UNDERSTANDING THE BASICS

Soil [illegible]

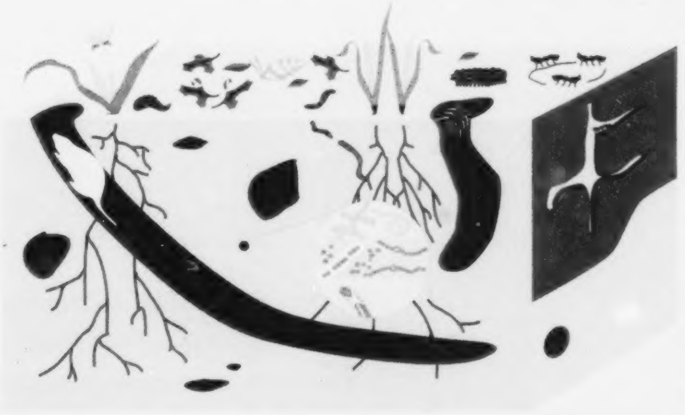
The goal of every farmer is to have healthy, productive soils that have:

- ►Consistently high yields,
- ►Minimal erosion by wind or water, and
- ►Minimal losses of nutrients or pesticides.

The diagram in the sidebar shows what healthy, productive soil looks like.

On the surface:

- ►Soil is covered with crop residue to protect it from wind and water erosion. The residue also slows moisture loss during the growing season.
- ►Water moves into soil soon after a rainfall and will not pond on the surface.



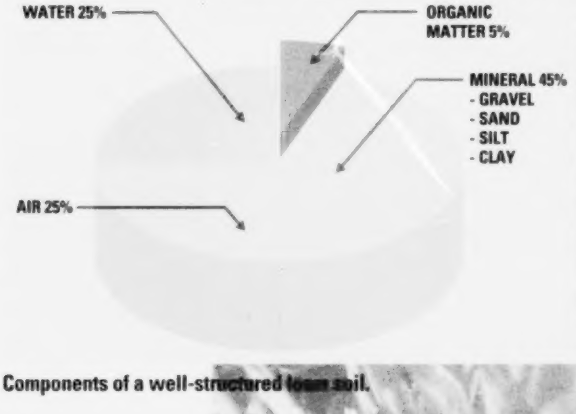
Well-managed soil has a wide variety of living things.

Below the surface:

- ►The soil favours root growth by having a proper mix of large and small pores.
- ►Organic matter helps hold moisture.
- ►The soil has sufficient fertility.
- ►Organic matter and soil life (bacteria, fungi, earthworms, insects, etc.) help to cycle nutrients.

Let's take a closer look at the make-up of soil. A shovel full has four parts:

- ►Mineral material.
- ►Air.
- ►Water.
- ►Organic matter.



Components of a well-structured loam soil.

TYPE	% SAND	% SILT	% CLAY
SANDY LOAM	[illegible]	[illegible]	[illegible]
SILT LOAM	[illegible]	[illegible]	[illegible]
LOAM	[illegible]	[illegible]	[illegible]
CLAY LOAM	[illegible]	[illegible]	[illegible]
CLAY	[illegible]	[illegible]	[illegible]

These are examples of soil texture. Percent of sand, silt and clay may vary within a texture.

SOIL TEXTURE

The largest part, about 45% of the volume, is mineral material. That is what you can see and feel. Sand, sandy loam, clay loam, clay, etc., describe soil texture. The proportions of sand, silt or clay determine soil texture. This table shows examples of percentages for five different soil types.

Ideally, about half the soil should be empty space, split evenly between water and air. The space in soils is called soil porosity. Two things affect porosity: soil texture and structure. The particle size, or texture, affects the amount of soil space because large particles, such as sand, create larger pores than small particles, such as clay. The ideal soil is based on loam which has the most equal portions of the three types of particles.

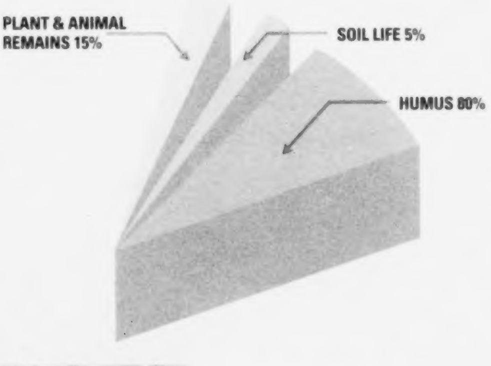
SOIL STRUCTURE

Soil structure refers to the mineral and organic particles being held together by sticky, binding substances (clay and decayed organic matter) to form larger clumps (aggregates) of soil. In healthy soil, these clumps stay together when wet and so resist breakdown by wind and water. This, in turn, reduces the chance of erosion and crusting.

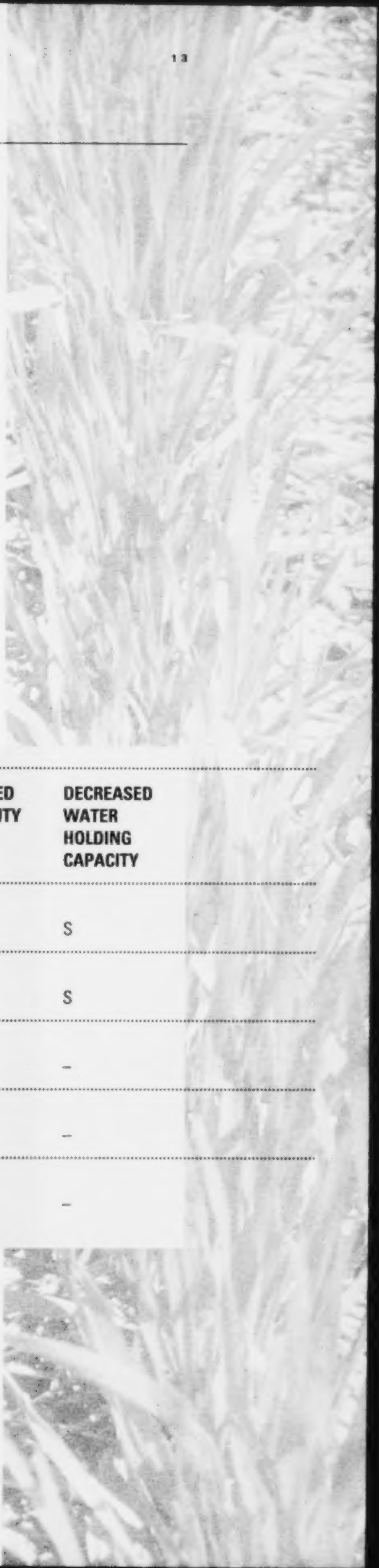
The clumps should be variable in size with pores between them. This allows for root growth and air circulation. A clay soil with good structure could be more porous than a sandy soil. When a soil with good structure is squeezed in your hand, it readily crumbles. This type of soil is usually found in fence rows, woodlots and in forage fields.

The final part of the soil, about 5%, is organic matter. About 80% of organic matter is humus, a stable material, which does not break down easily. This part helps the soil store water and nutrients and reduces erosion. It also makes the soil attractive to soil life and easier to work (improves soil structure).

Another 15% of the organic content is the remains of plants and animals which can break down quickly. The rest is living creatures such as earthworms, insects, bacteria and nematodes.



Types of organic matter.



arthworms and soil insects help to break down the larger pieces of plant residue so that acteria can further break them down. This contributes to the nutrient cycle. The undreds of kilometres/hectare of burrows that an earthworm creates, help root growth nd improve drainage. Other soil life feeds on plant material and on each other.

rganic matter is a part of soil that you can affect. Excessive tillage and poor crop otations speed the loss of organic matter. The table shows the impact of organic matter osses on different types of soil. Crop residues and manure combined with crop rotations elp to maintain or improve levels of organic matter. These additions also help improve oil structure and increase the soil's ability to hold water. The nutrient balance will mprove and with it, yield potential. Improved soil structure also increases air pore space nd helps soils resist compaction.

THE EFFECTS OF LOSS OF SOIL ORGANIC MATTER

SOIL	INCREASED CRUSTING	SLOWER MOVEMENT OF WATER INTO AND THROUGH THE SOIL	INCREASED CHANCE OF SURFACE COMPACTION	INCREASED ERODIBILITY	DECREASED WATER HOLDING CAPACITY
Sandy materials at surface	–	–	–	–	S
Loamy surface material over sand or gravel	–	–	–	S	S
Loamy material with a high sand content	–	S	S	S	–
Loamy material with a high silt content	S	S	S	S	–
Clayey material at surface	S	S	S	S	–

= Susceptible – = Not Susceptible

TYPE	% SAND	% SILT	% CLAY
SANDY LOAM	58	30	12
SILT LOAM	20	60	20
LOAM	45	35	20
CLAY LOAM	28	36	36
CLAY	18	32	50

These are examples of soil texture. Percent of sand, silt and clay may vary within a texture.

SOIL TEXTURE

[illegible]

[illegible]

SOIL STRUCTURE

[illegible]

[illegible]

[illegible]

[illegible]

Types of organic matter

[illegible]

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SOIL	INCREASED CRUSTING	SLOWER MOVEMENT OF WATER INTO AND THROUGH THE SOIL	INCREASED CHANCE OF SURFACE COMPACTION	INCREASED ERODIBILITY	DECREASED WATER HOLDING CAPACITY
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Loamy surface material over sand or gravel	–	–		[illegible]	
Loamy material with a high sand content	–	S	S	[illegible]	
Loamy material with a high silt content	S	S	S	[illegible]	
Clayey material at surface	S	S	S	[illegible]	

[illegible]

Tile drainage is an important part of soil management.

Drainage

Good soil drainage helps both the grower and the environment. It increases the air-filled spaces in the soil which, in turn, improves yield. Other benefits of good drainage include:

- ► Increased efficiency of fertilizers.
- ► More rapid warming of the soil in the spring.
- ► Improved soil structure.
- ► Reduced soil erosion because surface run-off decreases.

Some of the practices which improve drainage also improve other parts of the system. Examples are:

- ►Do not overwork the soil. Pulverizing the soil increases the risk of surface crusting which, in turn, increases run-off and makes it difficult for crops to emerge.
- ►Rotate row crops with cereals and forages. Root growth, especially with deep-rooted forages, opens up pores in the soil through which water can drain.

Soil Compaction

Soil compaction reduces the percentage of pore space in soil. It can cause problems with any tillage system. Compaction can occur near the surface or below the plow layer. Compaction below the plow layer is caused by loads in excess of five tonnes/axle. Surface compaction is caused by low organic matter, and excessive tillage.

In the case of surface compaction, tillage and sometimes, frost action, will break up the problem layer. When deep compaction occurs, the problem is much harder to fix. Root growth and wetting and drying cycles over a long period of time, may relieve the problem. Subsoiling is a Band-Aid solution at best and will likely cause more problems than it solves. The best remedy is prevention.

Reducing compaction risks:

Timing - use a crop rotation that spreads field operations over the full season.

Moisture - avoid field operations when the soil is wet at the working depth.

Control traffic - keep traffic patterns to limited areas of the field. Ridge till is ideal for keeping traffic off the row.

Reduce trips - reduce the number of trips and the size of the tractor.

Load distribution - keep axle weights below five tonnes/axle. Use trailers with tandem axles.

Narrow footprint - if possible, use tires with larger diameters rather than dual tires.

Radial tires - choose radial tires where extra traction is needed. These tires have up to 27% more surface contact than similar-sized biased ply tires.

4-Wheel drive vs. 2-Wheel drive - a tractor with 4-wheel drive distributes weight better between its axles than 2-wheel drive tractors.

SOIL SUITABILITY

When deciding what tillage system is best, you should consider the type of soil on your farm. Suitability depends on soil texture and drainage characteristics.

Soil Moisture

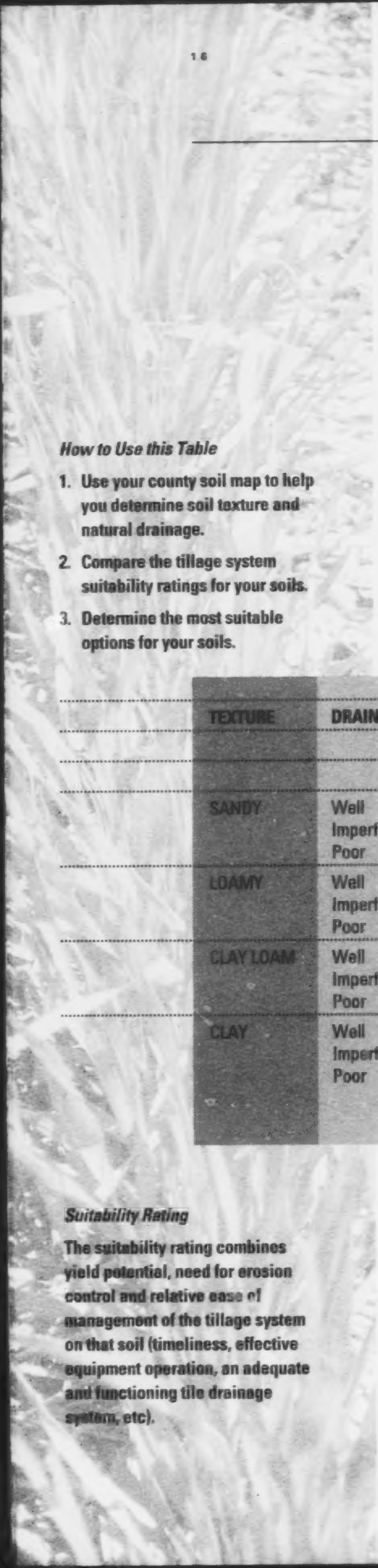
As more residue is left on the soil surface, less water escapes to the air and soil moisture may increase. Keeping moisture in the soil is good for light textured soils such as sands and sandy loams. Increased residue aids in moisture conservation. On heavier-textured soils such as clay and clay loam, increased soil moisture may pose a problem in early spring by delaying planting.

Reduced tillage tends to work best on well-structured, well-drained soils. The moldboard plow may be the best option on poorly-drained soils as they need working to speed the drying process. Advocates of ridge till report that ridged soil dries quickly and allows more timely planting. Ridge tillage may, therefore, be an option for reducing tillage on poorly-drained soils.

Texture

Texture and drainage go hand-in-hand when looking at soil suitability for a tillage system. Lighter textured soils such as sands and sandy loams work well in no-till and mulch till systems. Heavier, poorly-drained soils such as clay and clay loams need more tillage for soil drying.

Compaction can occur near the surface or below the plow layer.



Protection from Erosion

We know that some soils are not as likely to erode as others and are best-suited to the moldboard plow. Examples are clay and clay loam soils that are relatively flat. Other soils, particularly loamy and sandy soils with long or steep slopes, are very likely to erode. These soils need residue to protect them from water and wind erosion. Fortunately, these are the soils that are most suitable for no-till or mulch tillage systems.

The table (below) offers general guidelines for soil suitability for various tillage systems. If your soil structure is not average, then results for the tillage system may vary.

How to Use this Table

1. **Use your county soil map to help you determine soil texture and natural drainage.**
2. **Compare the tillage system suitability ratings for your soils.**
3. **Determine the most suitable options for your soils.**

SUITABILITY OF TILLAGE SYSTEMS ON ONTARIO SOILS

TEXTURE	DRAINAGE	YIELD*		EROSION		SUITABILITY RATING					
		MULCH TILLAGE	*NO-TILL*	*WATER*	*WIND*	*CONVENTIONAL*		*MULCH TILLAGE*		*NO-TILL*	
						FALL	*SPRING*	*FALL*	*SPRING*	*FALL*	*SPRING*
SANDY	Well	E	I	S	S	5	4	3	2	1	1
	Imperfect	E	I	H	S	4	3	2	1	1	1
	Poor	E	I	M	M	4	3	3	2	3	3
LOAMY	Well	E	E	S	H	3	3	2	1	1	2+
	Imperfect	E	E	H	M	3	3	2	2	1	2+
	Poor	E	E	M	L	1	2	2	3	2	4
CLAY LOAM	Well	E	D	H	M	3	3	1	2	1	3+
	Imperfect	E	D	M	L	2	3	3	3	2	4+
	Poor	E	D	L	L	2	3	3	4	3	4
CLAY	Well	D	D	M	M	2	3	3	4	1	4+
	Imperfect	D	D	L	L	2	4	4	4	2	4+
	Poor	D	D	L	L	3	4	4	4	3	4

YIELD POTENTIAL
I = Increase
E = Equal
D = Decrease
*** Compared to moldboard plow**

EROSION POTENTIAL
S = Severe
H = High
M = Medium
L = Low

SUITABILITY RATING
1 = Very Suitable
2 = Well Suited
3 = Moderately Suited
4 = Not Well Suited
5 = Not Recommended

+ Coulters on planting equipment to till a narrow strip of soil will improve rating.

Suitability Rating

The suitability rating combines yield potential, need for erosion control and relative ease of management of the tillage system on that soil (timeliness, effective equipment operation, an adequate and functioning tile drainage system, etc).

For example, well-drained sandy soil can be expected to yield as much with mulch tillage as under a conventional system. No-till could result in higher yields. Potential for wind and water erosion is severe. This type of soil is considered very suitable for no-till, both spring and fall, well-suited for spring chisel plowing, moderately-suited for fall chisel plowing and unsuitable for moldboard plowing.

ESTIMATED STRAW TO GRAIN RATIOS FOR SELECTED CROPS

CROP	STRAW: GRAIN RATIO
BARLEY	1.5:1
CORN	1.0:1
OATS	2.0:1
RYE	1.5:1
WINTER WHEAT	1.7:1
SPRING WHEAT	1.3:1

RESIDUE MANAGEMENT

Crop residue is beginning to be recognized as a resource rather than a nuisance. Residue is an important source of organic matter. If it is left on the soil surface or worked into the top few inches of the soil, organic matter levels can be maintained or increased. This helps improve soil structure and leaves the soil more manageable.

Residue management is an important part of farming operations. In the past few years, farmers, researchers and extension personnel have come to recognize that careful management of residue is the most cost-effective means we have of reducing erosion.

RESIDUE

- Protects the soil surface from the impact of rain.
- Reduces soil erosion.
- Reduces soil crusting and sealing.
- Adds organic matter to soil.
- Helps rain to soak into the soil.
- Reduces the loss of soil water to the air.

CROP YIELDS AND RESIDUE

All crops yield differently and supply various amounts of residue. Generally, higher-yielding crops produce more residue. Remember this when planning a residue management program for your farm.

The table (sidebar) shows the estimated straw to grain ratios for selected crops. For example, if a winter wheat crop yields 70 bushels/acre, there would be about 70 bu/ac x 60 lbs/bu x 1.7 or 7140 pounds/acre (8,000 kg/ha) of residue. This exceeds 95% residue cover. Of course, this number is an estimate and will vary with hybrid/variety, weather and the amount of straw removed at harvest.

[illegible]

RESIDUE COVER %	[illegible]	CEREAL STRAW KG/HA	(LBS./AC.)
20	[illegible]	400	(360)
30	[illegible]	500	(450)
40	[illegible]	850	(715)
50	[illegible]	1000	(880)
60	[illegible]	1300	(1160)
70	[illegible]	1700	(1520)
80	[illegible]	2200	(1960)
90	[illegible]	3000	(2680)
95	[illegible]	4000	(3570)

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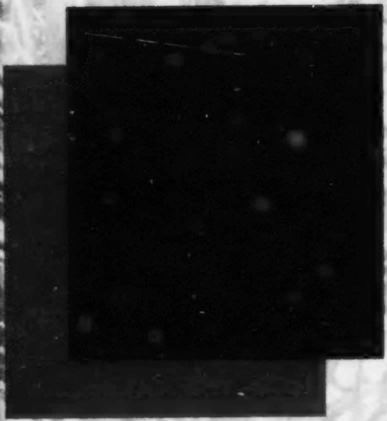
RELATING RESIDUE COVER TO WEIGHT OF RESIDUE

RESIDUE COVER %	CORN STALKS KG/HA	(LBS./AC.)	CEREAL STRAW KG/HA	(LBS./AC.)
20	700	(625)	400	(360)
30	1000	(890)	500	(450)
40	1500	(1340)	800	(715)
50	2000	(1780)	1000	(890)
60	2500	(2230)	1300	(1160)
70	3400	(3035)	1700	(1520)
80	4300	(3840)	2200	(1960)
90	5800	(5175)	3000	(2680)
95	7800	(6960)	4000	(3570)



Spread residue evenly behind the combine to eliminate windrows.

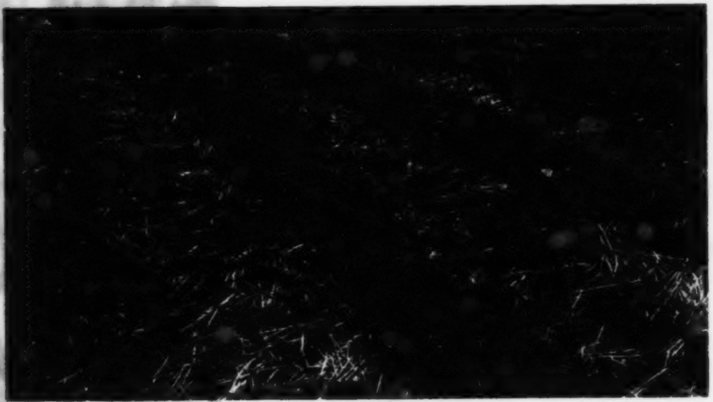
GOOD RESIDUE MANAGEMENT STARTS WITH HARVEST

To get good erosion control and, more importantly, to make tillage and planting easier, residue must be spread evenly behind the combine rather than windrowed. An even spread pattern protects more soil and reduces plugging problems with tillage and planting equipment.

Large-capacity combines with wide heads make even spreading of residue more difficult. Ideally, combines should be equipped with straw and chaff spreaders capable of spreading residue evenly over the full working width of the combine. Some combines may also require the addition of a shredder.

Disadvantages to windrows of straw or chaff left in the field are:

- Tillage implements become plugged with residue.
- Planting equipment may need modification to operate properly.
- Seed openers on planting equipment may push residue into soil (called hairpinning) which limits soil/seed contact.
- Certain types of residue excrete toxins as they decompose. These toxins may sicken or even kill the next crop (called allelopathy). Heavy accumulations of residue in the crop row may increase the chances of this problem. The toxins are most likely to be harmful when planting corn into corn or cereal stubble.
- Heavy residue insulates the soil and reduces the warming effect of the sun. Lower soil temperatures may slow seedling germination and emergence.
- Windrows of residue can intercept herbicides and prevent uniform application rates over the soil surface.



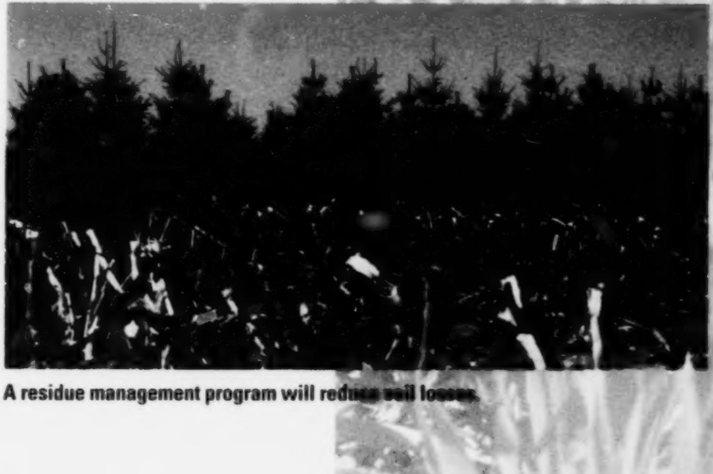
An even stand of soybeans emerging through wheat residue.

RESIDUE MANAGEMENT OPTIONS IN REDUCED TILLAGE

- ▸Grow hybrid/varieties with good stalk strength. This will make sure that the plant is still standing at harvest so the combine head can be set higher.
- ▸For small grains, set the cutting head on harvest equipment as high as possible without sacrificing yield. That way, more of the stalk is left in place and less passes through the combine.
- ▸Maintain an even speed when combining to avoid residue pile-ups when equipment slows. If you have to stop, back up to spread the residue.
- ▸Speak to your dealer to find out what changes you can make to your harvest equipment to improve the spread pattern for chaff and straw. Add-on equipment is available for most large-capacity combines. Before modifying your combine, make sure the changes will not alter the working capacity, endanger the operator or damage the combine.
- ▸Modify planting equipment with coulters or trash whippers to move crop residue out of the row area. This helps eliminate any toxic effects and clears the row so soils warm up.

Knowing the crop you will be harvesting and the amount of residue you may have to deal with gives you an idea of the options to consider. A good residue management program can:

- ▸Maintain or build soil organic matter levels.
- ▸Improve soil structure.
- ▸Conserve and recycle nutrients from previous crops.
- ▸Reduce soil losses due to erosion.
- ▸Reduce soil moisture losses due to evaporation.



A residue management program will reduce soil losses.

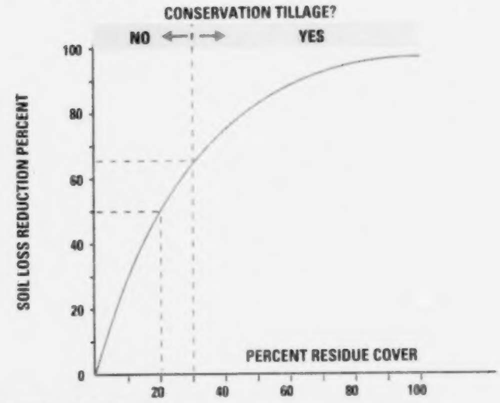
The examples show th[illegible] by 50% as compared to [illegible] 30% can reduce erosi[illegible]

EROSION AND RESIDUE MANAGEMENT

[illegible]

RESIDUE COVER AND SOIL LOSS REDUCTION FOR VARIOUS TILLAGE SYSTEMS

RESIDUE TYPE	TILLAGE SYSTEM	% RESIDUE COVER	% EROSION REDUCTION FROM MOLDBOARD PLOW
CORN	Moldboard plow, 2 cultivations, plant.	7	–
	Chisel plow, cultivate, plant.	35	74
	Disc, plant.	21	72
	Ridge till plant.	34	86
	No-till plant.	39	92
SOYBEAN	Moldboard plow, 2 cultivations, plant.	2	–
	Chisel plow, cultivate, plant.	7	32
	Disc, plant.	8	26
	Field cultivate, plant.	18	46
	No-till plant.	27	64
WHEAT	Moldboard plow, cultivate, plant.	9	–
	Chisel plow, cultivate, plant.	29	72
	No-till plant.	86	96



The examples show that 20% residue cover will reduce erosion by 50% as compared to a clean tilled field, while residue cover of 30% can reduce erosion by as much as 65%.

EROSION AND RESIDUE MANAGEMENT

When considering the best residue management program, examine what equipment you have and take a look at the average soil losses on your fields. Fields with high levels of wind and water erosion should have the most residue left on the soil surface. The diagram to the left shows how 20% residue cover reduces soil loss. As residue cover increases, the amount of soil saved increases too. When implementing a tillage system to reduce erosion, aim for at least 30% residue cover in order to reduce soil loss by 65% over a clean-tilled field.

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	Disc, plant	8	26
	Field cultivate, plant	18	46
	No-till plant	27	64
[illegible]	Moldboard plow, cultivate, plant	9	–
	Chisel plow, cultivate, plant	28	72
	No-till plant	86	96

The table shows the amount of residue you might expect after various crops under different tillage systems. It is important, both economically and to reduce erosion, to keep the number of trips over a field to a minimum. Crops, such as soybeans and field beans, leave very little residue and need very little tillage to prepare the ground for the next crop. In these cases, one or two light cultivations may prepare a good seedbed or no-till may be an option.

On the other hand, corn stalks and wheat straw leave the soil surface completely covered with residue. Too much residue may slow soil warming and drying to the point where planting is delayed and yield affected. High residue levels can also interfere with planting equipment, particularly in a mulch tillage system where the ground is loose beneath residue. If you are working the ground, aim to keep between 30 and 60% of the soil covered with residue.

You may want to modify your equipment to handle more residue. Be aware of your rotation and what crops are following each other. If soil warming and drying are problems, follow a rotation that alternates between high residue and low residue crops, such as corn and soybeans.

Best Management Practices for Residue Management

- **Spread residue evenly behind the combine to eliminate windrows.**
- **Know the amount of residue you will be dealing with by checking crop selection and tillage system.**
- **Choose residue levels that will reduce soil erosion.**
- **Use tillage equipment matched to your soil type, the amount of residue and farming needs.**
- **Modify planting equipment to handle residue left on the soil surface.**
- **Residue left on the soil surface or worked into the soil will maintain or increase organic matter.**

Good residue management means even emergence.

CROP ROTATION AND COVER CROPS

CROP ROTATION

Rotating crops is a best management practice because:

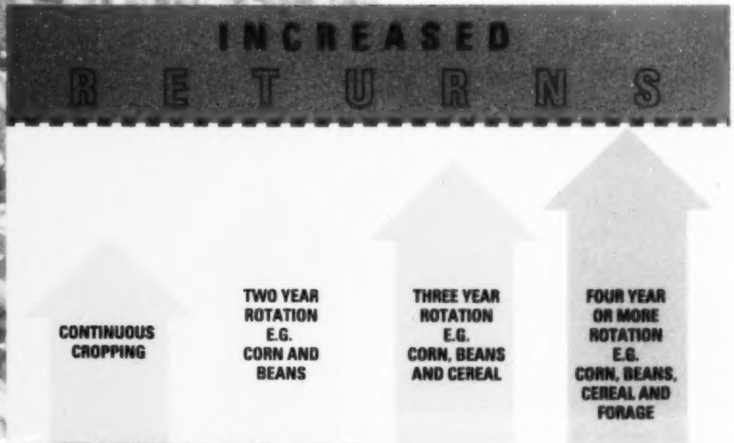
- ▶It reduces the risk of crop disease.
- ▶It reduces the population of pests specific to one crop.
- ▶It will increase the yields from a crop grown as part of a rotation compared to continuous cropping.
- ▶It can reduce soil erosion and run-off.
- ▶It spreads the workload for planting and harvesting over a longer time period as seasons vary with each crop.
- ▶It can complement each crop under rotation. For example, growing legumes provides nitrogen for non-legumes. And, alternating crops that successfully compete with weeds will reduce pressure on crops that do not.
- ▶By increasing crop yields and reducing inputs, profits on the combined crops can be higher.
- ▶Growers can stagger planting and field operations to avoid time pressures.
- ▶Special features of the farm can be taken into account, such as water resources, the nearness to markets and processing plants, special skills and labour availability.

At the same time, there are a few precautions that should be taken:

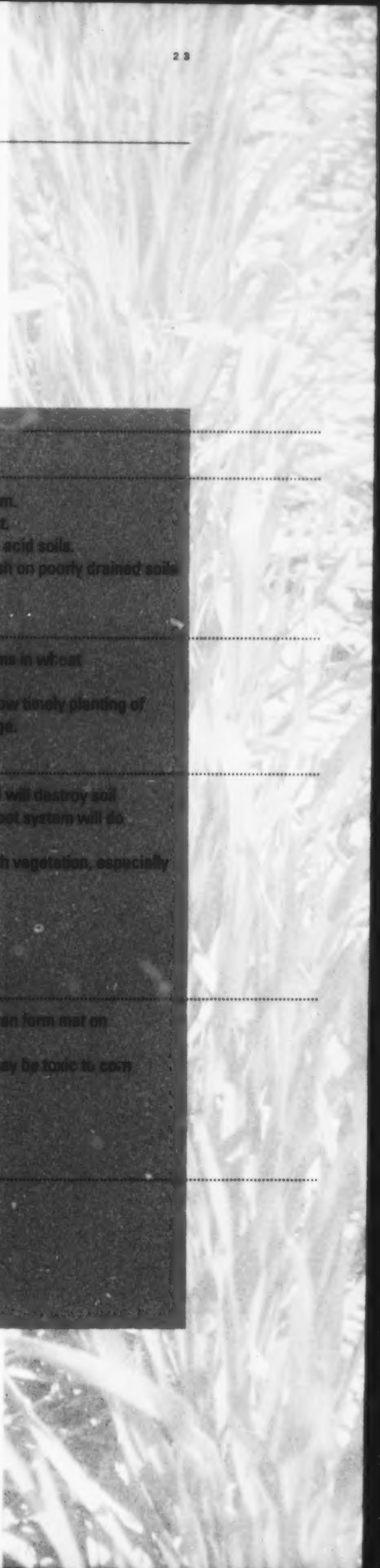
- ▶Planting times may conflict with critical phases of other crops such as weed control or an application of fertilizer that will boost yields.
- ▶ New management skills may be needed.
- ▶ Problems in one crop may make it difficult to manage another effectively.

The yields of corn and soybeans will improve if they are rotated with each other. By including a cereal in the rotation, yields and erosion control are improved. Adding a forage hay crop to the rotation improves yields and soil conditions even further.

If you are a cash cropper and cannot find land to put into forages, see if you can make a deal with a livestock-producing neighbour. That way, you have a market for the forage grown and get the benefits in your rotation.


INCREASED RETURNS
CONTINUOUS CROPPING
TWO YEAR ROTATION E.G. CORN AND BEANS
THREE YEAR ROTATION E.G. CORN, BEANS AND CEREAL
FOUR YEAR OR MORE ROTATION E.G. CORN, BEANS, CEREAL AND FORAGE

Crop rotations can increase net returns.



[illegible]

[illegible]	[illegible]	PRECAUTIONS
[illegible]	[illegible]	• High removal of potassium. • May be difficult to market. • Poor growth of alfalfa on acid soils. • Alfalfa difficult to establish on poorly drained soil
[illegible]	[illegible]	• Potential disease problems in wheat following corn. • Late harvest does not allow timely planting of fall-seeded crops or tillage.
[illegible]	[illegible]	• Preparing a fine seedbed will destroy soil structure and the small root system will do little to improve it. • Slow to cover ground with vegetation, especially when grown in rows.
[illegible]	[illegible]	• Large volumes of straw can form mat on ground after harvest. • Rye and wheat stubble may be toxic to corn crops and reduce yields.
[illegible]	[illegible]	

COMMON CROPS AND THEIR PROS AND CONS IN ROTATION

CROP	BENEFITS/CHARACTERISTICS	PRECAUTIONS
ALFALFA, CLOVERS	• Fix nitrogen for non-legumes. • Deep rooting opens soil pores. • Reduces soil erosion. • Planting is in spring, either alone or inter seeded into a cereal, or in summer following a cereal harvest.	• High removal of potassium. • May be difficult to market. • Poor growth of alfalfa on acid soils. • Alfalfa difficult to establish on poorly drained soils.
GRAIN CORN	• Produces high levels of residue which adds organic matter. • Tolerant to broad range of herbicides for weed control. • Early spring planting, later fall harvest.	• Potential disease problems in wheat following corn. • Late harvest does not allow timely planting of fall-seeded crops or tillage.
SOYBEANS	• Yields improve after corn. • Herbicide selection offers good control of grass weeds. • Later spring planting allows quackgrass control before planting. • Early fall harvest allows planting of fall seeded crops. • As a legume, it fixes its own nitrogen but does not leave an excess for the next crop.	• Preparing a fine seedbed will destroy soil structure and the small root system will do little to improve it. • Slow to cover ground with vegetation, especially when grown in rows.
WINTER CEREALS	• Planting season is in the fall which shifts workload, reduces amount of land to till in fall, provides winter cover. • Harvest during summer. • Extensive root systems improve soil structure. • Competition with weeds is strong so cost of chemical weed control is low.	• Large volumes of straw can form mat on ground after harvest. • Rye and wheat stubble may be toxic to corn crops and reduce yields.
SPRING CEREALS	• Planting season in early spring, before corn. • Harvest in summer. • Similar properties to winter cereals.	

Spring cereals make effective winter cover crops.

COVER CROPS

Effective use of winter cover crops is an important best management practice. Erosion potential of fall-plowed soil is high and cover crops can dramatically decrease soil loss. Smaller losses preserve the soil as a resource and maintain its nutrients. Erosion control by cover crops reduces the contamination of nearby watercourses.

Cover Crop Benefits

- Hold soil in place, preventing surface loss of nutrients or pesticides.
- Add organic matter and improve soil structure.
- Legume cover crops may provide nitrogen for next crop.
- Fall cover crops may hold soluble nutrients, and keep them from leaching.
- Vigorous cover crops will suppress weed growth.

Using Cover Crops

- Manage cover crops to use existing equipment as much as possible.
- Time planting to allow sufficient growth, but late enough that cover crop does not go to seed; e.g. red clover should be interseeded into cereals, or drilled in immediately after wheat harvest.
- Spring crops grown as fall cover have the advantage of dying over winter and don't need further control.
- Choose cover crops that will not interfere with next year's crop growth e.g. Buckwheat can carry white mould to next soybean crop. The best rotation alternates broadleaves & grasses.
- Cover crop control must be carefully timed, especially in no-till.
  - Red clover should be killed in fall.
  - Rye will grow from 30 centimetres (1 foot) to 1.5 metres (5 feet) in height in only a few days, if left uncontrolled and weather conditions are right.
- Only plant a cover crop you know you can get rid of.
- Use the cheapest cover crop that will do the job - most cover crop economic benefits are long-term.

NUTRIENT MANAGEMENT

Plants need 20 different nutrients for growth and seed production. Some are required in very small amounts while others make up the largest part of the plant. The most common elements in plant tissue (carbon, hydrogen and oxygen) come from the air and water. Nutrients like calcium, magnesium and sulphur are common in Ontario soils; although they are used by plants in fairly large amounts, they are not usually considered in fertilizer programs.

Primary nutrients (nitrogen, phosphorus and potassium) are the elements that most often have to be increased for crop growth. Plants use all three in large quantities. These elements make up the largest part of the farmer's fertilizer bill.

Micronutrients are used by plants in tiny amounts. They should be added when the plant shows signs of deficiency or when a soil test shows they are necessary.

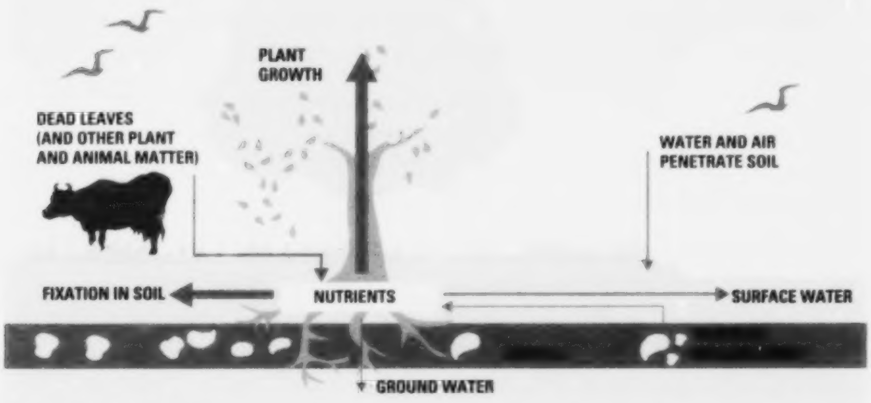
THE DYNAMICS OF SOIL AND FERTILITY

Soil fertility refers to the levels of nutrients available to growing plants. Some nutrients in the soil are not available to plants for the following reasons:

- They are in a chemical form that the plants cannot use.
- They are chemically bonded to soil minerals or clay particles.
- They are in the organic matter that has not yet decomposed.

Over time, these nutrients are made available through weathering and the actions of life forms in soil.

Erosion carries away soil and the nutrients that are in it. This particularly contributes to a loss of nutrients bound to the soil, such as phosphorus. Run-off carries sediment and dissolved nutrients downstream into watercourses. The diagram shows how gains and losses of nutrients occur.


PLANT GROWTH
DEAD LEAVES (AND OTHER PLANT AND ANIMAL MATTER)
WATER AND AIR PENETRATE SOIL
FIXATION IN SOIL
NUTRIENTS
SURFACE WATER
GROUND WATER

A simplified nutrient cycle.

The removal of crops takes nutrients from the soil too. These lost nutrients must be replaced with the addition of manure or commercial fertilizers. Returning crop residues to the soil helps lower nutrient loss. Returning nutrients to the soil completes a cycle sometimes referred to as the nutrient budget.

The rate of nutrient availability is influenced by the soil's level of acidity or alkalinity. The most suitable soil pH for many crops is near neutral (pH 7). If the pH level is outside the range of six to eight, nutrient availability will drop.

Only part of the phosphorus or potassium added as fertilizer or manure is available to this year's crops. They fix onto clay particles and soil minerals and are gradually released by microbial and chemical processes. Increasing the total content of phosphorus and potassium will increase the amount of nutrient release but care must be taken to avoid excessive application. Excess can hurt plant growth and contaminate run-off.

Nitrogen in the soil is part of a different cycle. There is lots of nitrogen in the air but a plant cannot use it in that form. It must be converted, either by legumes or in the manufacture of nitrogen fertilizer, into the ammonium or nitrate form which plants can use.

Nitrogen in the ammonium form can bind to soil particles. It can also be converted to nitrate, or absorbed by soil microbes. Plants can use ammonium nitrogen, but most is absorbed as nitrate. Unused nitrate can be lost by leaching as water moves through the soil, or it can be lost to the atmosphere.

Legume crops fix their own nitrogen from soil air with the help of bacteria. They do not require much nitrogen in the soil. Legumes, then, can capture nitrogen in the air and release it when their residues decay. Forage legumes can provide considerable nitrogen to the next crop, but most of the nitrogen from grain legumes is removed at harvest.

Nitrogen efficiency improves significantly if fertilizer is placed properly or if it rains soon after application. Because nitrogen, including that in manure, is so easily lost, it is best to inject it or work it into soil immediately after application.

Organic Matter

Organic matter within the soil is an important factor in soil fertility. As plant residues decay, the plant's structure breaks down into chemical building blocks. This releases nutrients into the soil solution and to growing crops. Organic matter also allows the soil to hold nutrients. If organic matter is not replaced by adding crop residues or manure, the fertility of the soil will decline.

SOIL TESTING

Soil testing is the only way of finding out what is in your soil. Anything else is just a blind guess. The process estimates the amount of a particular nutrient which a plant could use from that soil and calculates the amount of fertilizer that should be added for crop growth. Tests for phosphorus, potassium and pH can be taken at any time of the year with only minor changes in soil test levels. Nitrogen tests, though, must be taken at planting time because levels vary so much over the growing season.

The key to any soil testing program is taking a sample which reflects the field. A poor sample cannot give you accurate information. The following points will help make soil tests effective:

1. Take enough soil cores for the sample. At least 20 are required for fields up to five hectares (12 acres) in size, more for larger fields.

2. Take enough samples from the field. A sample is required for every 10 hectares (25 acres). If the field is larger, divide it into sections and take a sample per 10 hectares (25 acres). For phosphorus, potassium and pH, samples should be taken to a depth of 15 to 20 centimetres (6 to 8 inches) below the surface. Nitrate samples can be taken to a 30 centimetre (12 inch) depth but 60 centimetres (2 feet) is preferable.

3. Spread the core sites evenly across the field. The easiest way to do this is to zig zag up one half of the field and then back down the other half.

4. Many fields have areas that yield well and others that do not. This may be a result of soil type, drainage or past fertilizer and manure applications. Crops remove different

amounts of nutrients as the yield varies. If a crop on part of the field looks different or if an area has been treated differently with fertilizer, manure or lime, sample it separately. Do this even if the area is small.

5. If you plan to treat poor-yielding areas separately, test them separately. This is the best approach since it prevents over-application in high-yielding areas. Making a map of the poor areas will help in treatment.

6. Avoid sampling bands where fertilizer has been applied recently, dead furrows, areas adjacent to gravel roads, or where manure, compost or crop residues have been piled.

7. Try to take soil samples at the same time each year. Generally soil test values will give you the amount of nutrients to apply for maximum economic yield.

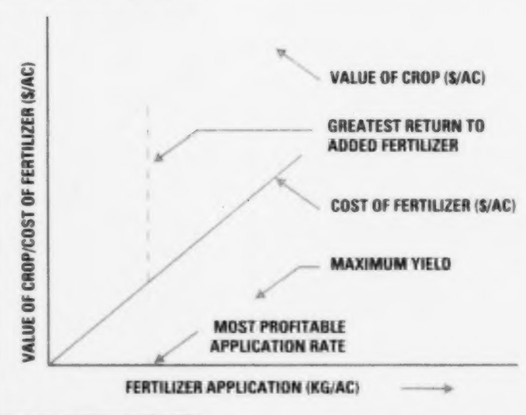
NOTE: Follow the directions given by OMAF on soil sampling kits. These are also found in OMAF Publication # 296 Field Crop Recommendations

MAXIMUM ECONOMIC VS. ENVIRONMENTAL YIELDS

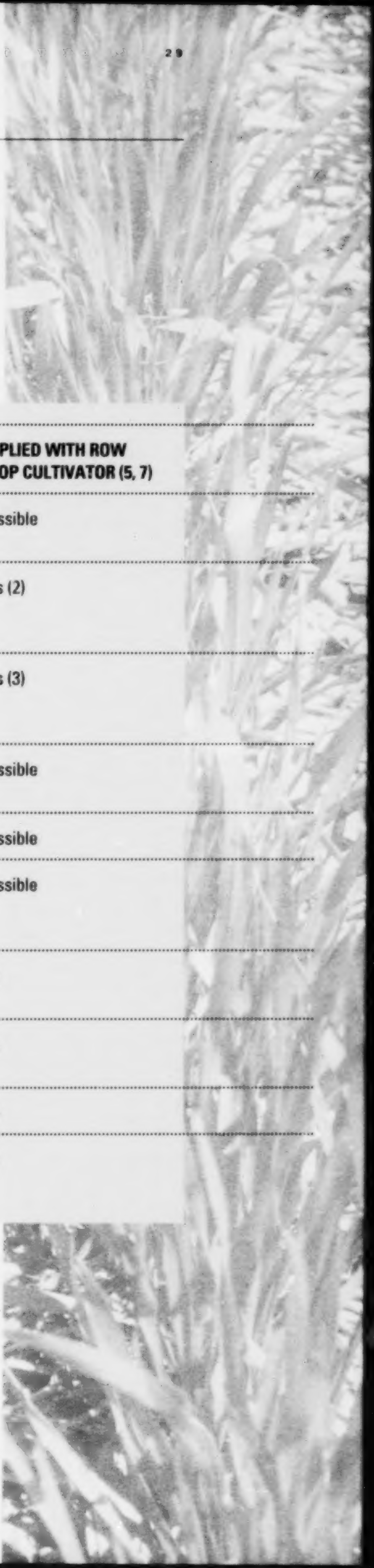
The maximum yield of a crop is reached when crop needs are well met. However, the maximum economic yield is the point at which the crop returns maximum profit. The graph shows that the two yields are often different.

As crop inputs rise, crop yields rise. Yields flatten out when the maximum yield is reached then begins to drop as excessive nutrients reduce yields. As the yield rises so does your gross income. The maximum economic yield occurs when the difference between expenses and gross income is greatest.

Maximum environmental yield occurs when all available nitrogen is used by the crop rather than left in the soil. Left-over nitrate nitrogen could leach into groundwater or run off into surface water. In most cases, maximum economic yield is also the point where the plant is making the best use of the fertilizer. This is also the maximum environmental yield for nitrogen. There may be some exceptions on very sandy soils. Further research is needed.



This graph shows the maximum economic yield for fertilizer application to a crop.



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FERTILIZER TYPE	SURFACE BROADCAST (6)	BANDED (8) AT PLANTING	KNIFED UNDER SOIL SURFACE (5, 7)	APPLIED WITH ROW CROP CULTIVATOR (5, 7)
ANHYDROUS AMMONIA (GAS)	No	No	Yes (1)	Possible
AQUA AMMONIA (PRESSURIZED LIQUID)	No	No	Yes (2)	Yes (2)
28%, 32% UAN SOLUTIONS (LIQUID)	Yes (3)	No	Yes (4)	Yes (3)
AMMONIUM NITRATE (DRY)	Yes	Yes (8)	Possible	Possible
UREA (DRY)	Yes (3)	No	Possible	Possible
10-34-0 SOLUTION AND OTHER LIQUID MIXTURES	Yes	Yes (8) (most common)	Possible	Possible
DRY PHOSPHATE MATERIALS	Yes	Yes	No	No
DRY POTASH MATERIALS	Yes	Yes (8)	No	No
DRY MANURE	Yes (3)	No	No	No
LIQUID MANURE	Yes (3)	No	Yes	No

NOTE:

1. Anhydrous ammonia is a gas and must be knifed into soil to prevent escape into the air.
2. Aqua ammonia is extremely volatile. It should be incorporated by knifing in or with applicators behind tillage teeth.
3. Nitrogen can escape into the air if not worked in soon after application or if rainfall is delayed, especially in warm weather.
4. Spoke-wheel injection will disturb soil the least for no-till systems. It is intended for side-dress application after the plant has emerged.
5. Application system is suitable for reduced tillage systems where broadcast fertilizer will not be worked in.
6. Applied before the seedlings are up.
7. Can be applied before the seedlings emerge or at the side after they are up.
8. Watch safe rates close to seed.

FERTILIZER TYPES AND APPLICATION TECHNOLOGY

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LIQUID MANURE	Yes (3)	No	Yes	No

NOTE

1. [illegible]
2. [illegible]
3. Nitrogen can escape into the air if not worked in soon after application. [illegible]
4. [illegible]
5. [illegible]
6. [illegible] conditions are [illegible]
7. [illegible]
8. [illegible]

FERTILIZER PLACEMENT – HOW AND WHY

Fertilizer is added to the soil in one of two ways: broadcast or banded. Although there are variations within each, the reasons for choosing one type over the other remain the same.

Broadcast

Broadcast fertilizer, as the name suggests, means spreading it over the whole soil surface, usually with a truck or tractor-drawn spreader. Fertilizer is usually mixed into soil by tillage, which helps improve efficiency rates. Nutrients may be lost if not worked in properly or may be tied up if soil fertility is low.

Broadcast fertilizer:

- ►Allows application of large quantities of fertilizer quickly.
- ►Requires less labour, is relatively low in cost, and there is little chance of fertilizer burn.

Banded

Banded fertilizer is applied in a narrow strip below the soil surface. This may be done at planting time or side-dressed after the crop is up, depending on the particular nutrient. Banded fertilizer is usually more efficient because it is placed where, and timed when, the plant can use it best. Efficiency is not affected by the form of fertilizer, whether solid, liquid or gas.

The following considerations apply to banded fertilizer:

- ►Allows starter fertilizer to be applied with or near the seed, giving an early boost in cool soils.
- ►Safe rates of fertilizer decrease as you get nearer the seed.
- ►Banded fertilizers are not tied up as quickly by the soil as broadcast fertilizers. This may give a yield boost in soils with low test results but makes no difference to soils with high fertility levels.
- ►The choice between liquid and granular fertilizers depends on cost and convenience. Both are equally safe and equally useful to the plant.
- ►Side-dressed nitrogen is more efficient than broadcast because it is placed close to where the roots are, at a time when the crop can make the best use of it.

Best Management Practices for Nitrogen Applications:

- ► **Apply nitrogen at the time when the crop requires it most. For corn, this means side-dressing most of the nitrogen when the corn is about knee-high. For cereals, this will be at the early tillering stage.**
- ► **Where possible, work in or inject nitrogen fertilizers to minimize loss to the atmosphere. As much as 30% of the nitrogen in soil-applied urea can be lost to the atmosphere in a week.**
- ► **If you must apply nitrogen to the soil surface, use a form that cannot be lost. This is especially important if there are high levels of crop residue on the surface. Ammonium nitrate or UAN are less subject to loss to the air than urea. No form of surface-applied nitrogen will be effective if rain does not wash it into the soil.**
- ► **Adjust rates to reflect the contribution of manure and legume plowdowns.**
- ► **Avoid surface applications during hot, humid conditions.**

Broadcast fertilizer is a low cost method of application.

SPECIAL CONSIDERATIONS FOR MANURE

In most of Ontario, manure is applied to large areas of farmland. Manure is a valuable resource that contains all nutrients. Properly managed, it can supply nutrient requirements and add organic matter to the soil. However, excessive rates that exceed crop needs are hazardous to the environment. They increase the risk of nutrients escaping into surface and groundwater.

Photo courtesy of Loyal Equipment Ltd.

Tractor-mounted manure injection into high residue corn.

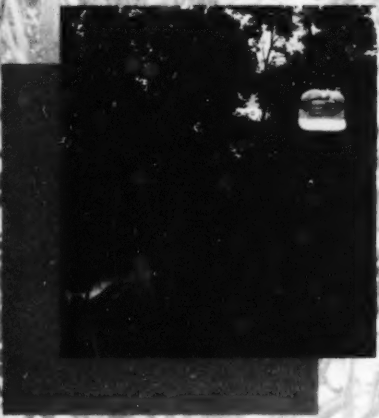
Best Management Practices for Nutrient Management:

- ▶Match nutrient requirements to crop needs and soil test levels. If a certain crop does not require much of a nutrient, don't overapply it. For example, if legumes do not need nitrogen, don't feed it to them. Put them into a rotation to benefit other crops that follow. Recognize that excess nutrients are potential pollutants.
- ▶Include the contributions from previous crops and manure when deciding how much commercial fertilizer is needed.
- ▶Complete regular soil tests for phosphorus, potassium and pH. Test for nitrogen when growing corn.
- ▶Reduce soil erosion to eliminate phosphorus and organic matter losses.
- ▶Maintain organic matter levels with manure, cover crops and residue to help cycle nutrients.

Best Management Practices for Manure Application:

- ▶ **Conserve the nutrient value of manure through proper storage and application.**
- ▶ **Avoid over application of manure to protect surface and groundwater from excessive nutrient loading.**
- ▶ **When applying manure, the rates of other fertilizers should decrease.**

NOTE: For further information, see the booklet on Livestock and Poultry Waste Management.



Scout fields regularly for weeds; insects and diseases.

PEST MANAGEMENT

Pest management includes the control of plants, insects or diseases that compete with a crop and restrict its growth. The best management practice is to prevent problems by using crop rotation and maintaining good soil fertility and structure. After all, a healthy, well-fed plant is best able to fight off pests.

Weed control aims to reduce nuisance plants to the point where the cost of damage to potential yield is less than the cost of control.

It is necessary to be balanced in your approach. Best management practices reduce the use of pesticides to the absolute minimum for your tillage system.

WAYS TO REDUCE PESTICIDE USE

Grow Crops Aggressively to Compete with Weeds.

Plant small grains and small-seeded legumes early so that they can become established and successfully compete with weeds that germinate later.

Narrow row spacing and increased planting densities increase the crop's ability to compete.

Drill soybeans, 18 centimetre spacing (seven inches), instead of planting in rows to increase their competitive edge. This practice will not allow cultivation and tramlines may be necessary to avoid tramping the crop when applying pesticides after crop emergence. However, Ontario research says that tramping the crop does not necessarily reduce yields if done early.

Use Cover Crops and Companion Crops as Biological Weed Control.

Cover crops compete with weeds and can provide a late season way to control weeds. Crops such as rye contain chemicals that retard weed germination and growth. Cover crops can compete with the main crop and reduce yields. Careful management is necessary.

If you seed forages into cereal nurse crops, the need for herbicides will be reduced. The cereal reduces competition from annuals such as ragweed and foxtail.

Scout Fields for Weed Problems Carefully and Regularly.

Identifying weed problems early may mean reduced needs for herbicides. Sometimes, weeds can be controlled by cultivation or rotary hoeing.

Walk all areas of a field to see which weeds need control and the weed's stage of growth. Sometimes, smaller weeds are hidden under taller ones. Sometimes, the problem is localized and requires only spot treatment. Make sure you treat weeds when they are at the proper stage of growth for control.

Keep a notebook or field maps showing weeds location when you are doing field operations. Record areas with problem weeds such as bindweed, quackgrass or Canada thistle. Treat the areas before weed growth gets out of hand.

Evaluate pesticide performance. If control is good, consider using a lower, recommended rate next time.

Rotate your Crops.

Changing the crop environment keeps weeds, insects and disease in check. Alternate crops that can successfully compete with weeds with those that cannot. Rotate crops that require different types of herbicides. Include crops that need little or no herbicide, such as cereals or pasture, in your rotation. This will help reduce the pesticide load on your soil.

Rotate the Pesticide Family.

Change the family of your insecticide each year. Insects can develop resistance to specific insecticides after repeated use.

Change the herbicide family too. By using the same herbicide over and over, weed problems will increase. Weeds that are resistant to the herbicide increase in number. For example, repeated use of atrazine has increased populations of triazine-resistant weed species such as Lamb's-quarters, Common Ragweed and Redroot Pigweed.

Make sure that you change the family of pesticides not just the chemical or brand. For example, alternating between atrazine and metribuzin (Sencor/Lexone) will not change family types. Both are triazine herbicides.

Keep Accurate Records.

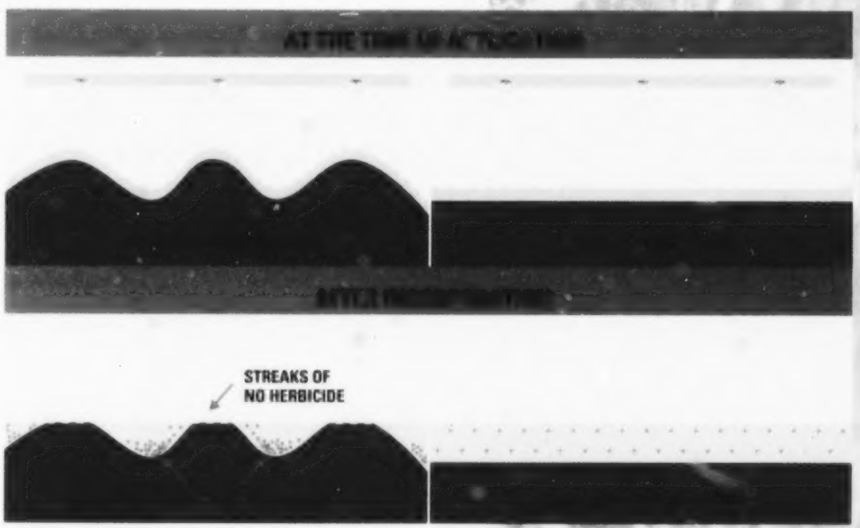
Record the date, rate, location, weather conditions (include wind speed, temperature, cloud cover, relative humidity), soil moisture, growth stage of crop and growth stage of weeds/insects/disease. Record the dates and amount of rain after application. Records will help you evaluate pesticide use and understand any problems afterwards.

Working Herbicides into Soil Requires Extra Management.

Some herbicides are more effective if incorporated. This also reduces loss to run-off because the herbicide is placed below the soil surface.

When you are incorporating herbicide, it's important to spray onto an even surface so that distribution is even. A rough surface may concentrate herbicide in valleys and clear it from ridges as shown in the diagram (below).

Read the product label carefully to know what type of incorporation is required. Some herbicides (Treflan and Edge) are immobile in the soil. While this is good for the environment, it becomes very important to thoroughly mix the soil so that herbicides are at the proper depth. Sprayed pesticide only goes half as deep as the depth of tillage on the first pass.



Apply pre-plant incorporated herbicides to level fields.

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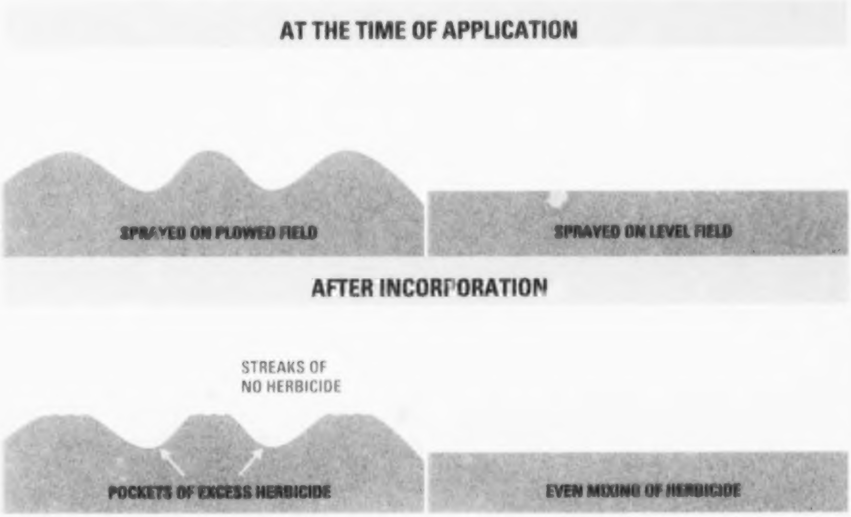

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Use Tillage to Control Weeds.

When you till to create a seedbed, weeds are controlled mechanically. Weeds and crops get an even start. Tillage can stimulate some weeds, as can warm soil temperatures in spring. Apply a soil-active herbicide at planting time to destroy the major weed flush.

With careful scouting, timely tillage operations and good weather, weeds can be controlled after planting. Use a rotary hoe to kill weeds before they emerge. After emergence, this is not effective.

Blind harrowing will also control weeds before they emerge. Drag the harrows across the field before weeds and crops emerge. This disturbs and kills shallow, germinated weeds without disturbing deeper crop seeds. This does not work after weeds emerge.

Inter-row cultivation also controls weeds. Effectiveness depends on the skill of the operator, the machine and careful adjustment.

Wet soil conditions can keep the tractor off the fields and allow weeds to grow beyond the point where mechanical control is effective. Post-emergent herbicides applied at this time are also ineffective. This is why some growers continue to include pre-emergent herbicides in their systems.

Band Herbicide Over the Row.

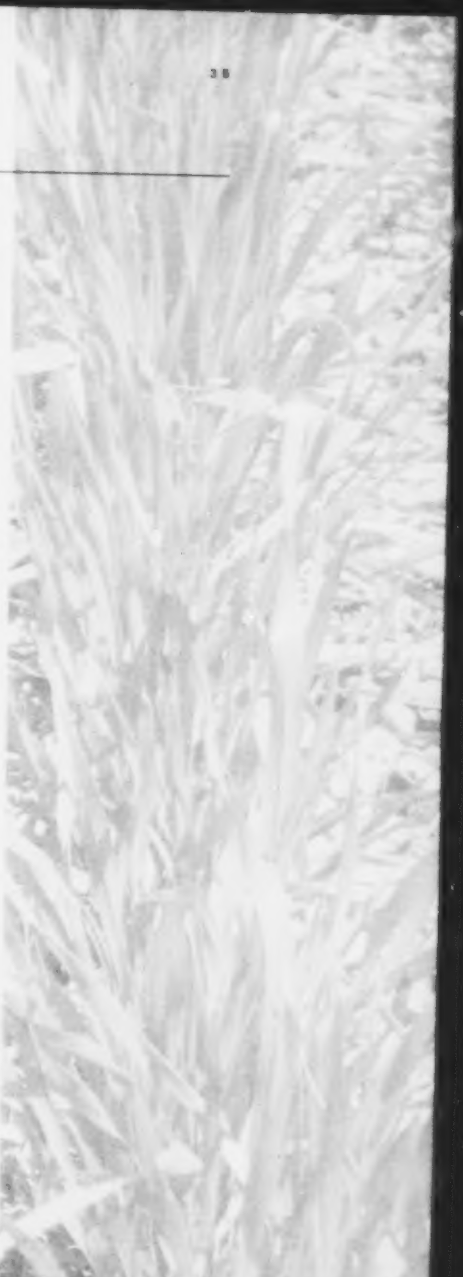
Banding herbicide over the row before crops emerge reduces the field area treated and the amount needed. Areas between rows can be treated with tillage or herbicides applied after crops emerge.

Use Herbicides Applied after Crop Emergence rather than Soil-Applied Ones.

Waiting until weeds are up will help you determine what needs to be controlled. This requires careful scouting and good weather at application. It's more demanding on the farmer too. This choice will only work if the right type of pesticide is available for the crop and will depend on its cost.

Consider the Economic Threshold of Control.

Controlling every weed in a field can require high and expensive rates of herbicides. You should only apply herbicides when the benefit from controlling the weeds will exceed the cost of the herbicide. This is especially true for post-emergence herbicides.



To complicate the decision, weeds that emerge from soil that has been treated with herbicide are often less competitive than weeds from untreated fields. The other factor to consider is the number of weed seeds produced. If the weed has potential to produce a lot of seeds (i.e. velvet leaf) in a field with no history of that weed, control is warranted. If there are only a few weeds, manual pulling is recommended.

Keep in Mind that Weeds Appearing late in the Season do not Reduce Yields as Much.

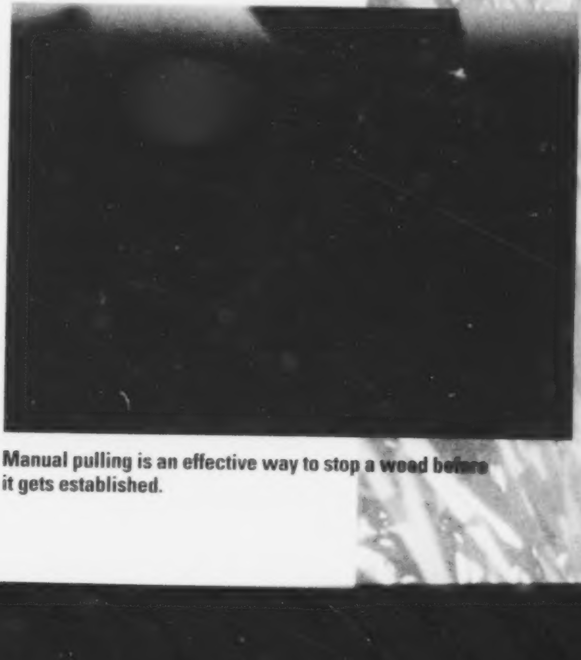
The critical time for weed removal is when the crop needs to be protected to prevent loss of yield. For corn in Ontario, as an example, the critical time starts at the third-leaf stage and continues until the tenth-leaf stage depending on weed density. No matter how much weed pressure there is, protection until the 14th-leaf stage will maintain yields. Spraying a late flush of weeds may make you feel better and prevent the weed from going to seed but it will not help crop yield.

Avoid Rescue Treatments.

Knowing what weeds to expect and using herbicides to control them will help eliminate extra passes over the field to catch "escapes".

Evalute Weed Control

Leave a small untreated check strip to evalute your weed control decision. The area can be burned off later with a backpack sprayer if there is a concern about weed seed production.



Manual pulling is an effective way to stop a weed before it gets established.

HOW LIKELY ARE MY PESTICIDES TO MOVE?

Losses of pesticides from the area they are applied depend on several factors.

FACTORS IN PESTICIDE LOSSES

CHEMICAL FACTORS:	**Solubility**	• Soluble pesticides will move easily with water and are more likely to leach.
	Binding to soil particles	• Some chemicals adhere very tightly to soil particles, and are not subject to loss.
	Rate of breakdown (half life)	• A persistent chemical, because it is around longer, is more likely to suffer loss than one which breaks down quickly.
	Rate of application	• A chemical with a low application rate is less likely to move away from the target.
	Timing of application	• Chemicals applied in the fall or early spring have a greater chance of loss.
SOIL FACTORS:	**Texture**	• Sandy soils, which allow greater water movement and bind less tightly to chemicals, are more subject to losses.
	Slope	• Steep slopes that are erosion prone are more likely to lose pesticides that are attached to soil particles.
	Depth to water table	• Shallow water tables are more easily contaminated. In the spring and fall when water tables are high, chemicals are more likely to move downward and contaminate the groundwater.
APPLICATION FACTORS:	**Weather following spray**	• Heavy rain within a few days of spraying can move significant proportions of the applied chemicals.
	Operator care	• Excessive rates, uncalibrated sprayers, careless handling, spraying too close to streams or watercourses, or spraying when it is too windy can all increase losses.

KEEP PESTICIDES ON TARGET

Prevent Groundwater Contamination.

Never fill the sprayer directly from the well. A well is a direct pipeline into groundwater. Spills near a well can contaminate groundwater in several ways:

- ▶ Directly from the surface.
- ▶ Through openings in and around the pump base.
- ▶ Through soil adjacent to the well.

Contamination can also be caused by backsiphoning. Backsiphoning is caused by gravity and refers to the backward flow of liquid from the sprayer into the well when the pump is shut off. To avoid backsiphoning:

HOW LIKELY ARE MY PESTICIDES TO MOVE?

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[illegible]

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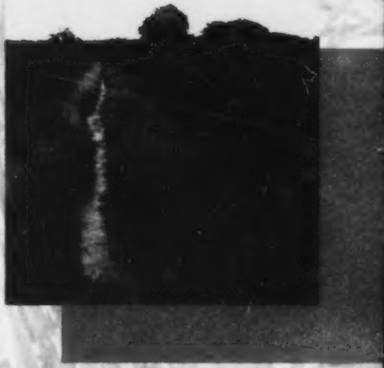
- ► Make sure the filler pipe or hose remains above the level of liquid in the sprayer. This keeps an air break between water and pesticide. Only submerge the water pipe or hose if it is equipped with special valves that prevent backsiphoning.

Do not rinse or wash the sprayer near a well.

Prevent Surface Water Contamination.

Use the same guidelines as with your well: Never fill the sprayer directly from surface water such as ponds, ditches or lakes. Rinse and clean your sprayer away from surface water.



Protect surface water from contamination by planting buffer strips.

Protect Surface Water from Spraying.

One of the easiest ways to protect water is to maintain a buffer strip of vegetation between it and the cropped field. Buffer strips reduce the risk of run-off of pesticides into watercourses.

Avoid Spraying if Heavy Rain is in the Forecast.

Heavy rain, immediately after application, can carry as much as 5% of atrazine and 3% of metalachlor (Dual) off the field. Rain one week after application does not cause significant losses. If it rains immediately after an application of a post-emergent herbicide, weed control will be reduced. This varies depending on the product. Consult the label.

Monitor Pesticide Rates Closely. Calibrate the Sprayer Accurately.

Apply pesticides at the recommended rate. If there is a range of rates, match the rate to your soil type and the level of the problem. Calibrate your sprayer carefully to ensure the proper rate of application. Using more pesticide than is needed is expensive, wasteful and increases the load on the soil unnecessarily. Some herbicides stay in the soil and may harm the next year's crop.

When Spraying, Reduce the Drift of Pesticides.

Big drops drift less than smaller drops. Low sprayer pressure produces larger drops. If applying pesticides before planting or before crops emerge, use large drops. After crops have emerged, application requires medium drops. Other ways to reduce drift include high water volumes [more than 170 l/ha (50 gallons per acre)] and use of larger nozzles. If the winds are higher than 8 kilometres (5 miles) per hour, delay spraying.

Reduce the Pesticide Load on the Soil.

The more pesticide applied, the more likely it will contaminate ground and surface water. Properly applied herbicides will break down before they are leached into groundwater. However, surface run-off may also contain pesticides. If control is good, try reducing to the low end of the registered rates. Be aware that all pesticides have their weaknesses, and these will be more likely to show at the low rates.

Herbicides such as atrazine, metalachlor (Dual), metribuzin (Sencor and Lexone) and simazine (Princep) have all been found in ground and surface water. For a list of herbicides showing their potential for loss, see the following table.

LOSS POTENTIALS OF SOME COMMON AGRICULTURAL CHEMICALS

PESTICIDE	SURFACE LOSS POTENTIAL	LEACHING POTENTIAL
ATRAZINE	Medium	Large
BANVEL	Small	Large
BASAGRAN	Small	Medium
BLADEX	Medium	Medium
2,4-D AMINE	Medium	Medium
DUAL	Medium	Medium
FUSILADE	Large	Small
LEXONE, SENCOR	Medium	Large
LINURON	Large	Medium
POAST	Small	Small
ROUNDUP	Large	Small
TREFLAN	Large	Small
COUNTER	Medium	Small
DYFONATE	Large	Medium
BAYLETON	Medium	Medium
TILT	Medium	Medium

Source: Farm Chemicals Handbook.

NOTE: This table reflects the chemical properties of the active ingredients. Risk will also vary with application properties.

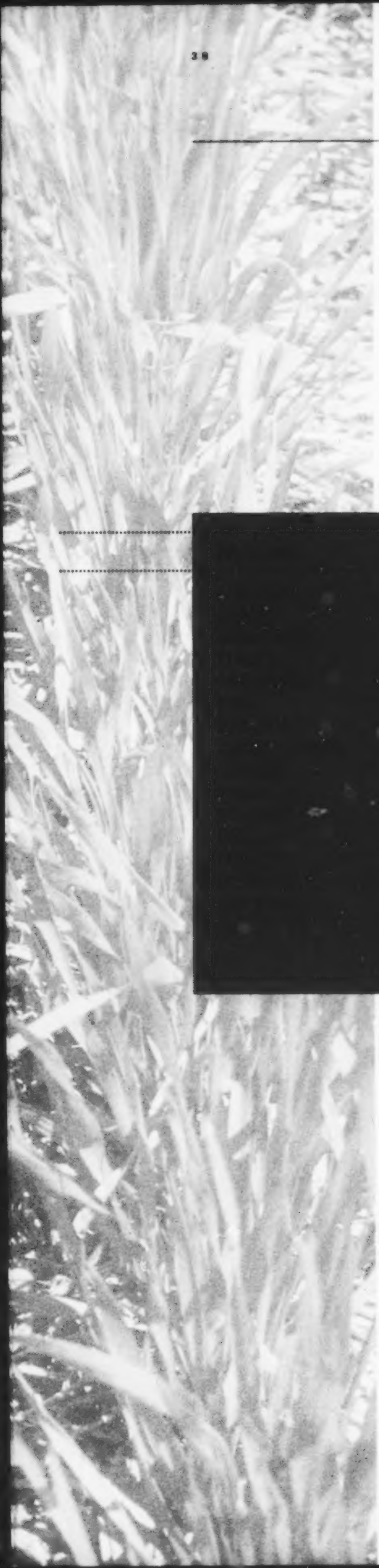
Handle Carefully and Be Prepared in Case of Emergency.

Read all product labels carefully. Wear protective clothing and have an action plan in case of a spill or poisoning. Emergency phone numbers should be posted near the phone and everyone on the farm should be completely familiar with emergency procedures.

If a spill does occur, confine it to the area where it took place and then, call the Ministry of Environment for clean-up help.

Best Management Practices for Pest Management

- ► Rotate pesticide families.
- ► Reduce chemical use.
- ► Calibrate the sprayer and apply pesticides carefully.
- ► Rotate crops.
- ► Use buffer strips and cover crops.
- ► Follow directions on the label.



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[illegible]

[illegible]	LEACHING POTENTIAL
[illegible]	Large
[illegible]	Large
[illegible]	Medium
[illegible]	Medium
[illegible]	Medium
[illegible]	Medium
[illegible]	Small
[illegible]	Large
[illegible]	Medium
[illegible]	Small
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FIELD [illegible]

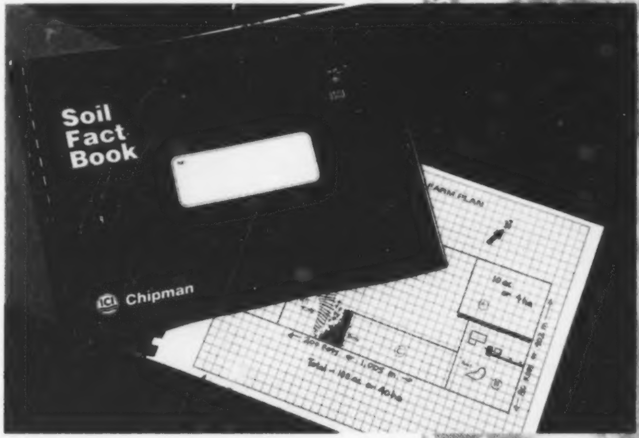
Planning what will happen in a field and then recording the details are important in evaluating your practices. Records help establish the conditions that led to success but they are particularly important if something goes wrong. Looking back at your notes may help determine what caused the problem. Working from memory alone does not provide enough information for useable answers.

Records for each field should include:

- ▶ All applications of pesticides, fertilizers and manure.
- ▶ The variety of seed used.
- ▶ Include both rates and dates of operations.
- ▶ Record weather conditions at spraying such as air temperature, wind speed, relative humidity.
- ▶ Record soil conditions when doing field operations.
- ▶ Note yields and crop quality.

Evaluate the success of your management and compare your results to research programs. There may be further improvements that you haven't considered.

There are field record books available from the Soil and Crop Improvement Association.



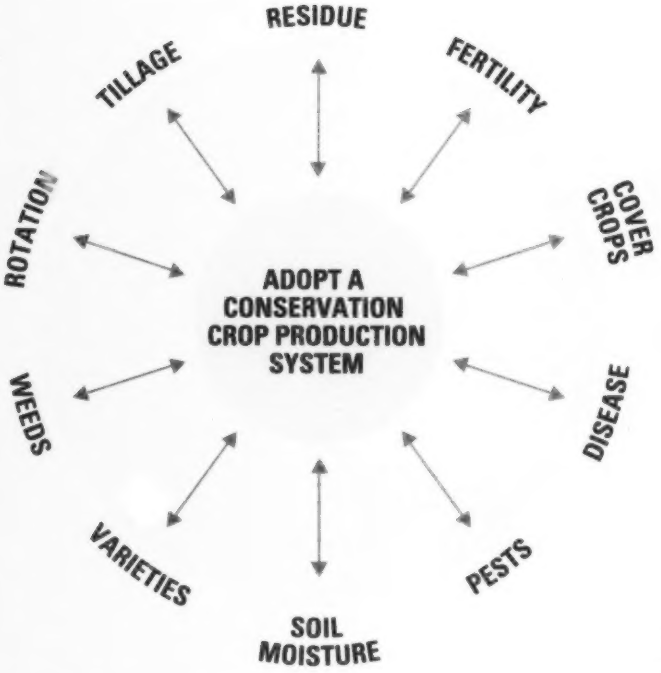
APPROACHING CHANGE

THE SYSTEMS APPROACH

A crop production system includes all of the components that you can control while growing crops, such as production practices, products used and soil characteristics.

To maintain production at profitable levels, you must consider a **conservation** crop production system. Careful attention to each component of a conservation crop production system will ensure both profitability and environmental responsibility.

Develop a system that works on your farm. Start by carefully analyzing the following:



Components of a crop production system.

Don Lobb

- ▸ Topography.
- ▸ Soil type.
- ▸ Livestock requirements.

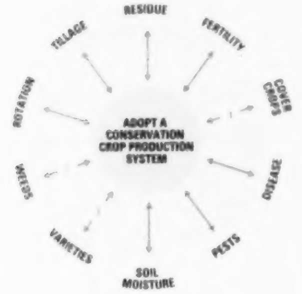
Get technical assistance to understand the possible effects of each change in production. This will ensure that change is profitable and effective.

- ▸ Many of the components which you can control are listed outside the crop production circle.
- ▸ Each component affects the production system and the system affects each component. Each time you change one part of your system, such as tillage or herbicide, there may be a chain reaction. Consider how a change might affect other components (see examples on next page).
- ▸ If you use a combination of practices and products which are complementary, crop yields will increase.
- ▸ Considering the impact on other system components applies to any new practice no matter what tillage system is used.
- ▸ Tillage is only one crop production component. Changing tillage will not necessarily change yields more than a change to another component.
- ▸ The application of this approach to new crop production practices improves the chance of good results.

THE SYSTEM IN ACTION

Let's look at some examples:

A producer using mulch tillage or conventional tillage decides to grow a red clover cover crop (1)seeded into wheat. The reason for the change is to improve soil structure and to reduce the need for commercial nitrogen for a corn crop which is to follow.

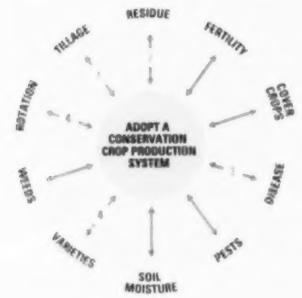

RESIDUE
FERTILITY
COVER CROPS
DISEASE
PESTS
SOIL MOISTURE
VARIETIES
WEEDS
ROTATION
TILLAGE
ADOPT A CONSERVATION CROP PRODUCTION SYSTEM

Don Lobb

Because of the change, fall weed control of field bindweed is not possible because the herbicide used regularly would kill the clover (2).

Now, the system needs a new weed control program for the bindweed. It will now be sprayed while it flowers during the corn crop season. However, the corn variety used may have low tolerance to the herbicide (3) so a new corn hybrid has to be selected to maintain yield.

By introducing one change, a chain reaction begins. A cover crop change leads to altered weed control which leads to a change in corn varieties.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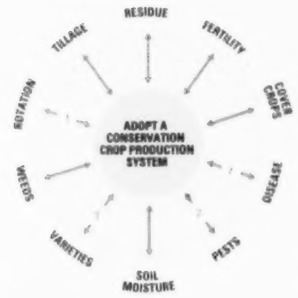
In another case, a producer decides to use no-till corn production to reduce soil erosion and equipment costs. The following chain reaction takes place: The move to no-till corn (1) leads to increased residue (2) which in turn increases the risk of stalk disease (3) which causes the producer to re-select the corn variety for disease tolerance (4) or to change the crop rotation (4) to limit disease carry-over.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Don Lobb.

And finally, a ridge till producer decides to change his crop rotation from corn/corn/soybeans to corn/soybeans/wheat to eliminate the use of a corn rootworm insecticide. A secondary benefit is improved corn stalk quality. Therefore, he selects a new variety to make sure corn yield is increased. The chain reaction is as follows: The change in crop rotation (1) reduces the use of pesticides (2) and reduces plant disease (2) which allows a change in corn variety (3).

Remember, to make your system work, consider how a change of one component will affect the other components in the system.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE

Conventional tilled fields are usually moldboard plowed

As mentioned in the introduction, this booklet defines conventional tillage as systems which attempt to cover most of the residue, leaving less than 30% residue cover on the soil. The moldboard plow is commonly used along with other tillage equipment.

The following section gives information on best management practices that maintain soil quality and reduce soil loss.

SOIL MANAGEMENT

A well structured soil is important for all soils in a cropping system.

Some conventional systems provide little residue, or leftover plant matter, to return to the soil. That is why some soils have poor soil structure and do not work up easily. To improve soil structure and fertility in a conventional system, look at practices that return organic matter to the soil. These include crop rotations, using cover crops, adding manure, and reducing tillage to leave residue on the soil surface.

SOIL LOSS WITH CONVENTIONAL TILLAGE

Conventional tillage with the moldboard plow creates the highest risk for soil erosion. Soil loss varies with slope, the amount of run-off, soil organic matter levels and the amount of residue cover. Soil plowed in the fall, left with little or no residue, loses more soil to erosion than soil managed with any other type of tillage system.

To reduce erosion in a conventional system:

- Keep the ground covered. Include forages in the rotation or maintain cover crops between regular crops.
- Increase residue cover. Modify your plow to leave more residue on the surface.
- Plow across the slope. Follow the curvature of the land.
- Contour plant row crops so rows follow the contour rather than up and down the slope.
- Strip crop. Plant a field with alternating strips of two or more crops such as cereal or hay with row crops. Plant along the contours of the field.
- Terrace the field. Terraces are structures that control water run-off in a field.

See the section on Non-tillage Options for more information on contouring, strip cropping and terracing.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE

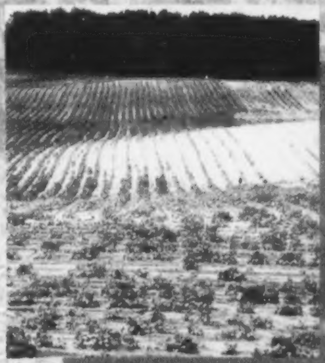
Tillage Erosion

It is easy to see evidence of severe soil loss on the upper slopes of fields throughout Ontario. Exposed subsoil and undercut fencerows on slopes of ridges and knolls are obvious signs. Severe erosion of upper slopes may be caused by a process called tillage erosion. When soil is worked, the action of the tillage implement lifts soil and moves it forward. Gravity pulls the soil downhill when it is disturbed. The net result is that soil moves down the slope with tillage.

Research done in Ontario estimates that over 100 tonnes per hectare of soil is lost from upper slopes each year. Additional erosion by wind and water can increase the rate to over 150 tonnes per hectare. An acceptable level would be four tonnes per hectare.

To reduce tillage erosion, take the following steps:

- Reduce tillage trips. Eliminate all unnecessary trips over a field.
- Reduce the intensity of tillage. Soil movement increases with the depth and speed of tillage operations.
- Vary tillage patterns. Using the same pattern to work a field each year results in some areas being worked upslope and others being worked downslope. This means increased losses in some areas of the field and will increase variation in the field over time. Vary the pattern used wherever possible so that all areas are tilled upslope as often as downslope.
- Reduce the size of implements. The natural action of the equipment is to level the soil. By reducing the width of equipment, the degree to which soil is levelled will change.
- Switch to other tillage sytems. If your farm is particularly vulnerable to tillage erosion, you might consider mulch or no-till systems.
- Take areas out of production. If it is not possible to reduce tillage erosion or soil is degraded to the point that it is too expensive to reclaim, consider retiring the area.
- Contour plow.



Knolls with light-coloured subsoil at the surface are evidence of past erosion by tillage, wind and water.

Reclaiming Areas that are Severely Eroded

Areas that are severely eroded cannot produce high crop yields because of poor fertility, low water-holding capacity and poor soil structure. The most productive layer of any soil is at the top and that is what is lost to erosion first.

To correct problems on knolls or slopes, make regular applications of manure. When applied regularly at recommended rates, manure will increase organic matter levels and improve conditions on severely-damaged soils. Forage-based rotations and green manure crops such as red clover also help rebuild the soil.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE

Best Management Practices for Soil Management:

Include the following in your cropping practices:

- ►Crop rotations that include forages.
- ►Cover crops to protect the soil and add organic matter.
- ►Manure incorporated into the top few inches of the soil surface.
- ►Reduce number of tillage passes to leave residue on the soil surface.
- ►Reduce tillage erosion by decreasing depth and speed of tillage.

RESIDUE MANAGEMENT

Normally, in a conventional tillage system, we do not talk about residue management. Residue is normally plowed into the soil and the ground is left bare. It is possible, however, to reap some of the benefits of surface residue in a conventional system.

Equipment can be modified to leave some residue on the soil surface. See the equipment section for some modification ideas. If you have some lighter-textured soils, try plowing in the spring instead of in the fall. Crops that leave little residue cover after harvest could be left to the spring and the soil worked with a cultivator or disc.

Cover crops can provide some extra residue to protect the soil. If possible, leave the crops on the soil surface as long as possible to reduce spring erosion. Remember cover crops must be controlled by either tillage or herbicides so they will not become weeds in the next crop.

Rotations should include both broadleaf and grass type crops.

CROP ROTATION

Crop rotation is a best management practice. A short rotation that alternates grass type crops with broadleaf crops (i.e. corn-soybeans-wheat-red clover) helps reduce soil erosion, eliminate pest and disease problems and spread the work load out over the growing season. Including a legume crop, such as alfalfa in the rotation will also improve soil structure, build organic matter, and supply nitrogen to the next crop.

NUTRIENT MANAGEMENT

The best management practices for nutrient management in a conventional system are covered in the Understanding the Basics section.

Remember it is key to soil test your fields and find out what fertilizer requirements are needed for your crops. Fertilizer rates should be adjusted for manure applications or legume crops that are grown in the rotation.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE

PEST MANAGEMENT

In a conventional system, it is important to scout your fields and control pests accordingly. Always follow product labels for proper control measures. The Understanding the Basics section covers the best management practices for pest management in a conventional system.

EQUIPMENT

THE PURPOSES OF TILLAGE

Soil aeration - tillage loosens and aerates the soil.

Management of residue - with tillage, residue will be buried, mixed into the soil, left on the surface or chopped. Too little residue will leave the soil open to erosion or crusting, but too much may interfere with some tillage and planting equipment.

Incorporating fertilizer - tillage will work fertilizer and manure into the soil.

Weed control - tillage will bury weed seeds and disturb growing weeds to kill them. Tillage will smother weeds by burying them.

Soil clod breakdown - tillage creates a mix of particle sizes for good seed-to-soil contact and easy operation of planting equipment.

Incorporating herbicides - tillage improves the performance of pre-plant incorporated herbicides by mixing them with the soil.

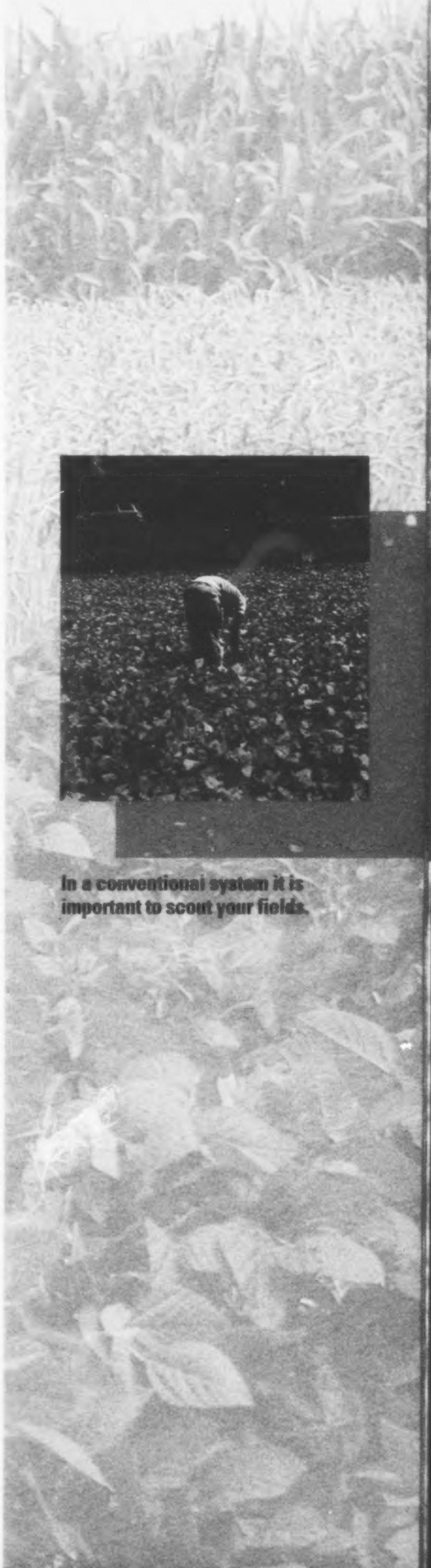
Moisture management - tillage reduces excessive moisture at planting. Bare soil dries and warms up faster then residue covered soils.

Seedbed Structure

One goal of tillage is to allow good seed-to-soil contact for seed germination and crop growth. Fine-textured soils such as clays and clay loams require loosening and a reduction in the size of clumps before crops can be planted.

Fall primary tillage shatters and loosens the soil in order to aid root penetration and growth. Frost action reduces the size of clumps, which increases the area available for root growth.

Secondary tillage produces a layer of soil with particles in the range of 0.5 to 5 mm (.02 - .2 inches) in diameter. This gives the most seed-to-soil contact which allows good germination. It will also limit the moisture lost to evaporation. Do not pulverize the soil, or a heavy rainfall will form a crust that cannot be penetrated by seedlings. A finer seedbed is necessary in dry soil to help draw up soil moisture from deeper soil depths.



In a conventional system it is important to scout your fields.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE

Proper plow adjustment will leave some residue on the soil surface.

PRIMARY TILLAGE EQUIPMENT

The Moldboard Plow

The moldboard plow lifts and fractures the soil. It also incorporates residue, manure and fertilizer. Plowing is a first step in providing a good seedbed. An uneven job of plowing will require extra tillage passes in the spring to level out the ridges left by the plow.

Most moldboard plows work best within a specific speed range. At low speeds, the plow may not fracture the soil and will leave more residue on the surface. By increasing the speed, the soil clumps will be broken down into finer sizes and the plow will bury more residue.

Fall Plowing

In the fall, the soil surface of heavier soils (clay, clay loam) should be left rough and cloddy. Then, frost can act on more of the soil surface. Frost action over the winter is important in improving the structure of heavier soils. When ice forms in the soil, the pressure of the water expanding will break the soil clumps into smaller particles. After repeated cycles of freezing and thawing, the average clump size is reduced. Avoid secondary tillage and working the seedbed very fine in the fall as this will leave the surface susceptible to erosion.

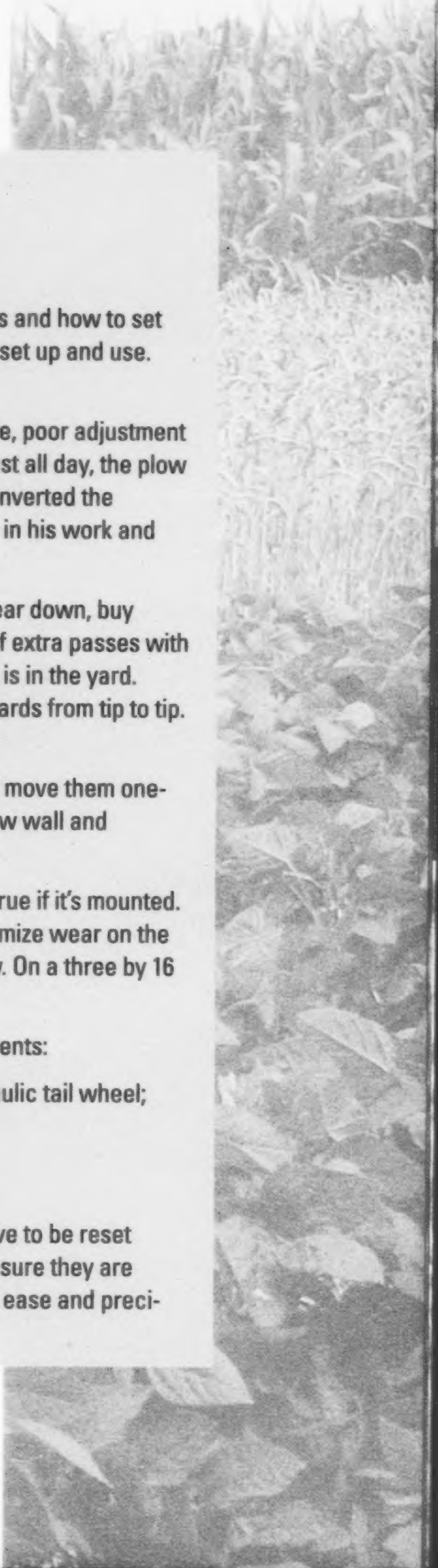
Spring Plowing

Spring plowing is an option for lighter-textured soils such as sands and sandy loams. The guidelines for spring plowing differ from fall plowing. In the spring, the plow should create a smooth, fine-textured seedbed. Harrows or packers may be pulled behind the plow if the soil is dry. This prevents excessive soil drying and will produce an acceptable seedbed. Additional secondary tillage may or may not be required to produce an adequate seedbed. It will depend on the crop to be grown and the type of job the plow did.

Spring plowing is not recommended for heavier soil types. The soil may not dry enough in the spring to allow the plow to properly shatter the soil. Clods will form in wet soils and will be difficult to break down with secondary tillage. This creates a poor seedbed which will tend to dry out during the growing season. In the spring, soils tend to be wet when plowing should be done. If plowing is done on wet soil, compaction will occur which damages the soil and reduces crop yields.

By plowing in the spring rather than in the fall, you reduce soil erosion. For the lighter soil types such as sands, sandy loams with small amounts of residue on the surface (i.e. soybean stubble), you may try not plowing at all and just top working the soil. This will eliminate erosion even further and help preserve soil moisture.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE



Proper Plow Adjustment is not as Easy as it Sounds

By Ron Bailey, New Liskeard College of Agricultural Technology carried in Ontario Farmer, November 13, 1991.

Is your plowing finished? If it is, are you proud of it? If so, don't read this. It is not for you.

So you are still reading, then this article is for you because it is all about moldboard plows and how to set them up. I agree that the moldboard plow is the most difficult piece of farm equipment to set up and use. Yes, that includes the combine.

Have you ever studied the intricacies of, and adjustments on, an old riding plow? On those, poor adjustment couldn't be overcome with more horsepower or more fuel. To get the team of horses to last all day, the plow had to be set and used like the precision instrument it was. It sliced through the soil and inverted the furrow. Winging, nosing and heeling could not be tolerated by a plowman who took pride in his work and cared for his team.

The same applies today, but it is easier to get away from improper adjustment. We just gear down, buy more fuel and pay for costly and unnecessary wear. And a poor job just needs a couple of extra passes with the discs next spring. But it's easier to do the job right in the first place. The place to start is in the yard. Check the plow. Sight along the mouldboards. Are they even? If not, measure the moldboards from tip to tip. Perhaps the braces need adjusting.

Now check the coulters. Set them to cut approximately one-third of the furrow depth and move them one-half inch to three-quarters inch out from the landside. This will give you a nice clear furrow wall and prevent the shin from loosening the wall up.

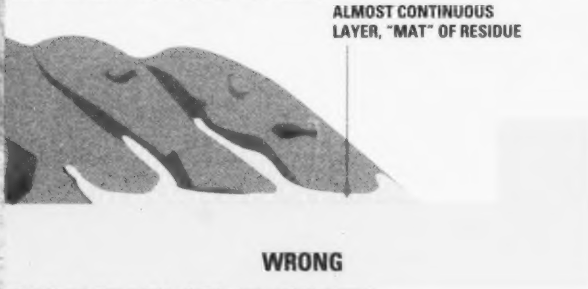
Did you know your tractor wheel spacing should be set for your plow? This is especially true if it's mounted. Wheel spacing is important to prevent the tractor from being pulled sideways and to minimize wear on the plow. The proper setting is furrow width X number of furrows + one-quarter of one furrow. On a three by 16 for example, spacing from inside to inside is 52 inches.

Now that is done, we are ready to plow. Drop the plow in and make the following adjustments:

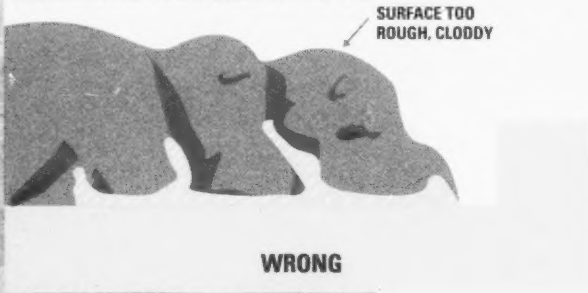
1. Level the plow front to back (use a level and/or tape measure) with the top link or hydraulic tail wheel;
2. Level the plow from side to side by adjusting the lift link on the tractor; and
3. Set the front furrow width equal to the others with the cross shaft or landing.

NOTE: That the right side tractor wheels must be in a furrow or these adjustments will have to be reset once the first furrow is made. Now check the coulter adjustments and furrow widths to insure they are correct. If your plow is not badly worn, it should slice and invert the furrow with the same ease and precision of grandfather's old riding plow.

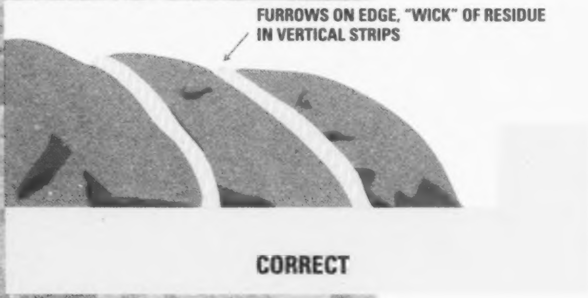
TILLAGE OPTIONS – CONVENTIONAL TILLAGE



Furrow slope too flat, plow set too shallow.



Furrow slope too steep, plow set too deep.



Good furrow shape.

Managing Residue with the Moldboard Plow

In situations with large volumes of residue being plowed, such as with grain corn, plows may plug with residue. Use a plow with high clearance (greater distance between the beam and the plow bottom) because they are designed to handle large volumes of material. They may even handle residue immediately after harvest without discing or chopping stalks first. This reduces labour and energy inputs.

For the best residue management:

- Use the stubble bottom plow or European bottom plow to leave residue on the surface. (The sod bottom or general purpose bottom plow buries more residue).
- On plows with variable furrow width, narrow the furrows to increase residue cover.
- Remove covering blades attached to the top of the moldboard to increase surface residue.

Plows that leave each furrow on its edge, as done by the European models, manage residue better than those which invert the soil. Inverting the soil leaves crop residue in a single, continuous layer beneath the surface. This "mat" of residue traps water above it which reduces water soaking into the subsoil. This in turn, leads to run-off and reduces soil moisture reserves during droughts. By trapping water near the surface, the mat may delay field operations and hurt crop growth during wet weather.

Moldboard plows with bottoms that place the soil on edge leave residue in strips which avoids problems. Residue forms a "wick" which helps water evaporate and traps snow.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE

Modifying the Moldboard to Increase Residue Cover

Modifying the moldboard plow will increase surface residue.

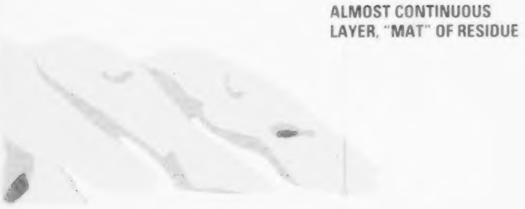
Because the moldboard plow was designed to turn over soil and bury residue, it is not always easy to modify it to leave residue on the surface. There are some things, however, which can be done without sacrificing plow performance.

- ▸Remove the trash covers. This will leave the "wick" of residue open to the soil.
- ▸Adjust the plow. With a wide bottom plow that runs too shallow, the furrow will tend to completely invert and no residue will be left on the surface. The best plowing depth is one-half the width of the bottoms. On a variable width plow, narrow the bottoms and plow shallower to increase the amount of residue left on the surface.
- ▸Cutting back the moldboard will increase the amount of residue but it should be done carefully. A large part of the moldboard would have to be removed to leave significantly more residue. This may affect the draft of the plow. Some people have had success removing the moldboard completely and using the share and shin. At the moment this remains a matter of trial and error.
- ▸Consider a bolt-on kit with a combination sweep and twisted shovel. These, in effect, allow you to use the plow frame to create a low-cost chisel plow. Kits have proven quite effective for this purpose and are available from several companies. Caution must be exercised when making modifications to the moldboard plow, as some attachments change the draft requirements of the plow and it will be harder for the tractor to pull the implement straight.

SECONDARY TILLAGE EQUIPMENT

Secondary tillage equipment is used to level and prepare the seedbed. It is a best management practice to reduce the number of passes to a minimum. Excessive tillage is expensive and unnecessary. It will reduce the organic matter levels in the soil and cause extensive wind and water erosion problems.

Discs are used for secondary tillage to prepare the seedbed and work in fertilizer and herbicides. It tends to chop and bury residue, working in 30 to 70% in a single pass. The disc is a good levelling tool and its sharp edges penetrate hard surface crusts. The surface is left quite smooth, depending on the amount of residue left. The downfall of the disc is that water is likely to run off and wind may erode the soil. Discs can cause compaction if used in wet soil.



WRONG

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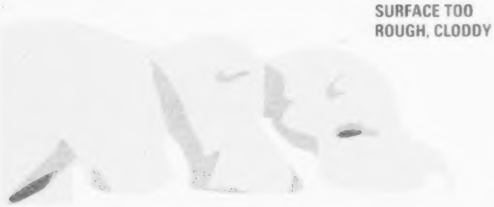

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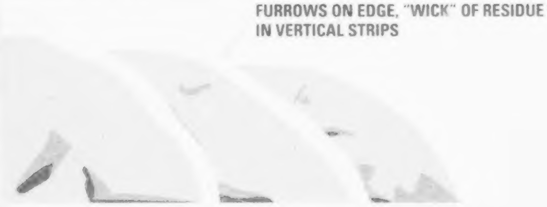

CORRECT

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TILLAGE OPTIONS – CONVENTIONAL TILLAGE

Field cultivators shatter clumps and sort them by size. Coarser lumps are brought to the surface while finer ones accumulate at lower depths where the seeds are planted. This also brings residue to the soil surface. Cultivators with stiff tines operate better in high-residue conditions than flexible S-tines. However, the field cultivator does not handle residue as well as the disc. Some of the newer models have greater frame clearances to handle residue. They are often followed by a cultipacker or harrow to firm the soil and improve its ability to retain moisture.

Harrows are usually used along with another tillage implement. They smooth the soil and break lumps that are moist enough to shatter. Tines that face backwards are better at crushing clumps than forward-facing tines. Chain-type harrows are better at clump crushing than spike-tooth harrows. Harrows may be used to break up soil crusts and to control germinating weeds after planting.

Cultipackers are used to firm the seedbed and to reduce clump sizes. They may be pulled behind other tillage equipment to save one trip over the field. They also level the soil. Be careful that the packer does not leave soil too fine which can cause crusting.

Combination tillage equipment combines different implements on a single frame. It reduces the number of trips over the field yet still prepares the proper seedbed.

Row cultivators have tines and blades that disturb the soil between crop rows to kill weeds. There are many models to choose from. Modern automatic guidance systems can help the operator avoid cultivating the row itself. Inter-row cultivation breaks up the soil crust, allowing rain water to soak in. It can reduce moisture loss by creating a surface mulch.

The rotary hoe is a series of sharply-spoked steel wheels. The wheels are tightly spaced in a row or two. The hoe, operated at relatively high speed, is used to shatter surface crusts and disturb weed seedlings. It may be used shortly after planting to help crops emerge through a crust or for weed control. It is more effective for weed control after the weed seeds have sprouted, but before they emerge.

Subsoilers are implements that operate at depths over 25 centimetres (10 inches) to loosen compacted layers of soil. If the subsoil is wet, it will be damaged by subsoiling. Unless the practices that caused compaction are changed, compaction will happen again. Unfortunately, the re-compaction of loosened subsoil will be greater than before the operation. In Ontario, subsoiling has not increased crop yields and is not recommended.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE

PLANTING EQUIPMENT

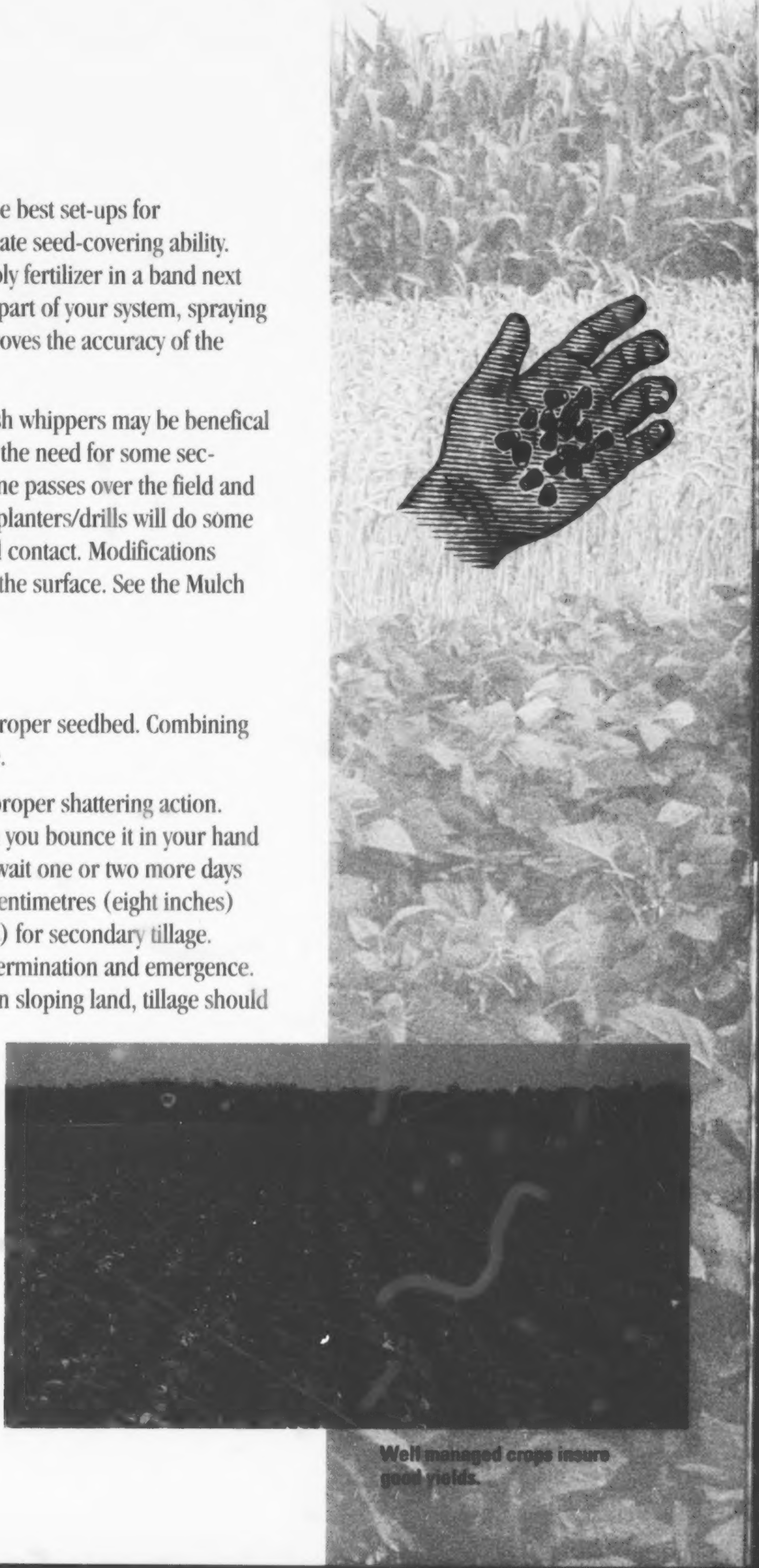
Planters and drills allow precision placement of seeds. The best set-ups for conventional tillage include precise depth control and adequate seed-covering ability. Conventional planters can include optional equipment to apply fertilizer in a band next to the seed row below the seed level. If banding herbicide is part of your system, spraying at the time of planting combines another operation and improves the accuracy of the application to the row.

Planters or drills that are modified with extra coulters or trash whippers may be benefical in a conventional system. Using modified planters eliminates the need for some secondary tillage to prepare the seedbed. This will eliminate some passes over the field and reduce the chance for erosion to occur. The coulters on the planters/drills will do some tillage to prepare the needed seedbed for proper seed-to-soil contact. Modifications on the planter/drill will help handle any crop residue left on the surface. See the Mulch Till or No-till/Ridge till sections for modification ideas.

TILLAGE OPERATIONS

Tillage passes should be kept to a minimum to prepare the proper seedbed. Combining operations to get the job done is a best management practice.

Tillage should only be done when the soil is dry enough for proper shattering action. Take a handful of soil and squeeze it. If it stays in a ball when you bounce it in your hand (does not break up) then the soil is too wet and you should wait one or two more days for it to dry properly. Depth of tillage should not exceed 20 centimetres (eight inches) for primary tillage or 5 to 10 centimetres (two to four inches) for secondary tillage. Tilling any deeper will only dry the soil out and cause poor germination and emergence. Deep tillage will bring unproductive subsoil to the surface. On sloping land, tillage should be done on the contour (across the slope) to help eliminate erosion.



Well managed crops insure good yields.

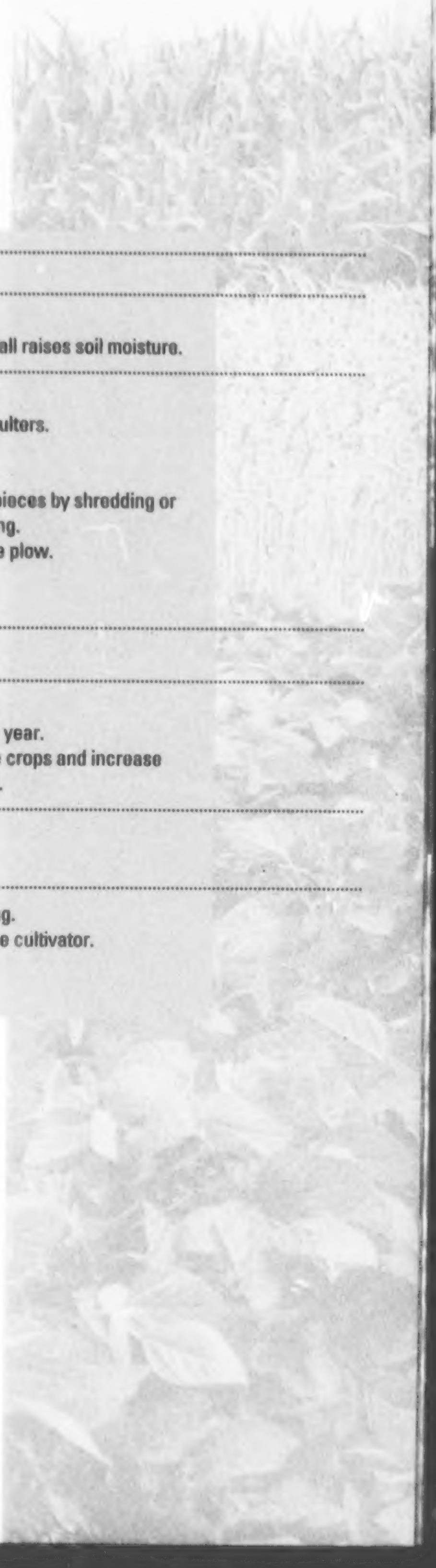
TILLAGE OPTIONS – CONVENTIONAL TILLAGE

Best Management Practices for Equipment and Tillage

- Read the instruction manual for your equipment. Learn how to set it and operate it properly.
- Properly maintain equipment. Down time during busy seasons is very costly if planting or harvesting is delayed.
- Check machinery regularly (daily or even twice a day when in use). Catching a problem in its early stages saves money and time. Early detection may prevent the small problem from developing into a large one.
- Operate the machine at the suggested speed and load. This gives peak performance and longer life.
- Replace parts when they are worn. Worn parts will not perform properly and will increase the horsepower requirement.
- Tillage equipment operates best when it is level in all directions. Level it front to back and side to side. Check that all depth gauge wheels operate at the same depth. These adjustments create even tillage.
- Combine operations on each field pass to reduce the number of trips over the field.
- Use only the implements necessary to create an ideal seedbed. Soil conditions and results will help you decide which combination of equipment is best. Once you've created a good seedbed, stop tilling
- Work the soil across the slope to eliminate water erosion.
- Work at the proper depth to prepare an adequate seedbed. Tilling too deep costs money and creates more wear and tear on machinery.

Best management practices for conventional tillage are numerous. If used properly, a conventional system can be environmentally friendly and save you some money. Take a look at the section on Non-tillage Options for more best management ideas that you can try on your farm.

TILLAGE OPTIONS – CONVENTIONAL TILLAGE



TROUBLE SHOOTING

PROBLEM	CAUSES	SOLUTIONS
[illegible]	• Plow points are worn • Soil is too dry	• Replace plow points. • Wait until sufficient rainfall raises soil moisture.
[illegible]	• Plow is not set properly • Residue coulters are not set at proper depth or distance from points • Residue volume is more than plow can handle • Plow doesn't have enough clearance between bottom and beam	• Check adjustments. • Check adjustments of coulters. • Chop residue into small pieces by shredding or discing soil before plowing. • Purchase high-clearance plow.
[illegible]	• Plow is not set properly	• Check set-up of plow.
Plow pan forms	• Performing field operations on wet soil	• Don't go onto wet fields. Vary plowing depth each year. Plant deep-rooted forage crops and increase organic matter in the soil.
Disc [illegible]	• Excessive speed • Disc is not level	• Slow down. • Level implement.
Field cultivator plugs	• Too much residue	• Disc soil before cultivating. Replace with high-residue cultivator.

TROUBLE SHOOTING

PROBLEM	CAUSES	SOLUTIONS
Plow will not stay in ground	• Plow points are worn • Soil is too dry	• Replace plow points. • Wait until sufficient rainfall raises soil moisture.
Plow is plugging with crop residue	• Plow is not set properly • Residue coulters are not set at proper depth or distance from points • Residue volume is more than plow can handle • Plow doesn't have enough clearance between bottom and beam	• Check adjustments. • Check adjustments of coulters. • Chop residue into small pieces by shredding or discing soil before plowing. • Purchase high-clearance plow.
Flowing is uneven, lumpy, ridging	• Plow is not set properly	• Check set-up of plow.
Plow pan forms	• Performing field operations on wet soil	• Don't go onto wet fields. Vary plowing depth each year. Plant deep-rooted forage crops and increase organic matter in the soil.
Disc ridges soil	• Excessive speed • Disc is not level	• Slow down. • Level implement.
Field cultivator plugs	• Too much residue	• Disc soil before cultivating. Replace with high-residue cultivator.

TILLAGE OPTIONS – MULCH TILLAGE

Mulch tillage leaves at least 30% of the soil surface covered by crop residue. In this section, we look at how practices change when moving from conventional systems into mulch tillage. Other terms that are sometimes used for this system include: **reduced tillage, minimum till or conservation tillage.**

Mulch tillage is the ideal system to use if you want to reduce tillage but have forages or manure to worry about. This system allows you to leave residue on the soil surface and work manure into the soil.

Changes from Conventional System

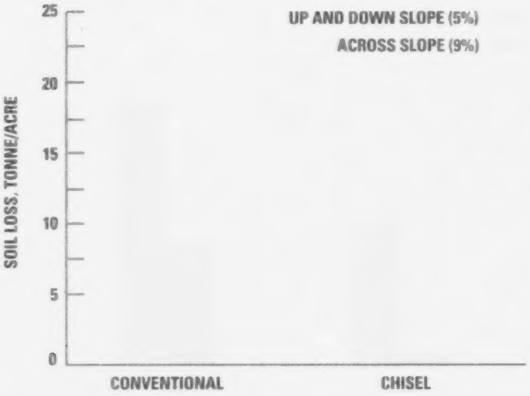
- ▶ **Mulch tillage is compatible with most soils except clays and imperfectly or poorly-drained clay loams.**
- ▶ **Soil temperature and moisture are affected, which may delay tillage or planting by a day or two.**
- ▶ **High levels of surface residue reduce soil erosion.**

After planting at least 30% of the soil surface is covered by crop residue.

SOIL MANAGEMENT

EROSION CONTROL

Residue Levels - from the section on Understanding the Basics, we know that different crops leave different amounts of residue. In a mulch till system, various amounts of residue can be easily handled with the proper equipment. By leaving residue on the soil surface, mulch tillage is one of the best systems for erosion control.



The effect of type of tillage and tillage direction on soil loss. A considerable advantage is shown for chisel plowing cross slope as compared to moldboard plowing in either direction or chisel plowing up-and-down slope.

Tillage Direction - tillage direction has a major effect on soil loss. As shown in the diagram, erosion is reduced dramatically if the land is worked across the slope instead of up-and-down the hill.

Eliminate Trips over the Field - clumps are broken down by tillage. The more a soil is tilled, the smaller these clumps become. The soil is then more likely to erode and crust. Limiting the number of tillage passes and leaving more residue near the surface not only reduces erosion and crusting but also increases the organic matter content at the soil surface. This makes soil easier to manage.

TILLAGE OPTIONS – MULCH TILLAGE

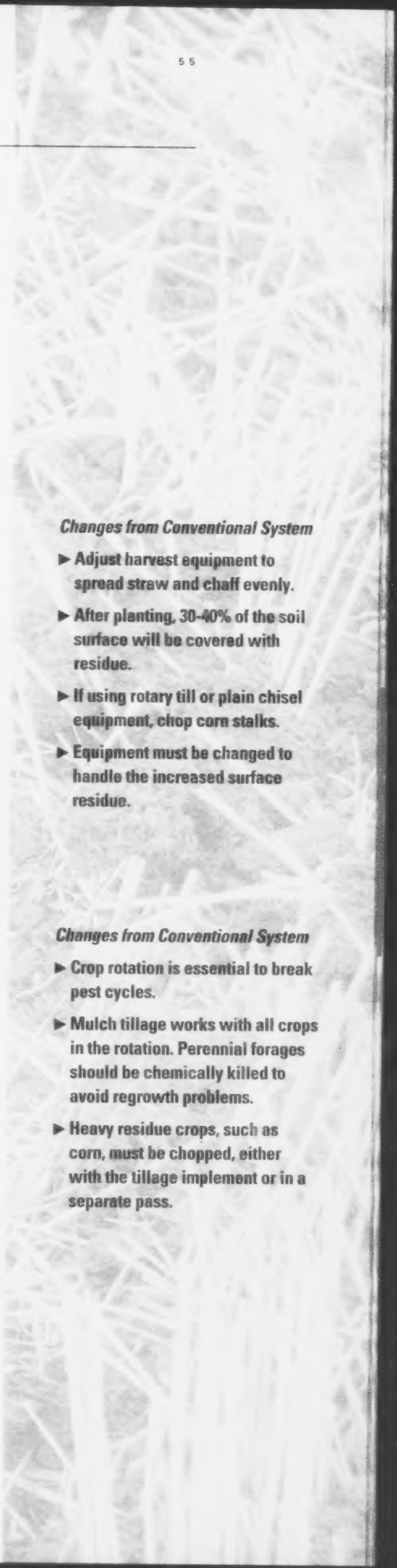
SOIL TEMPERATURE

Temperatures are influenced by the amount of residue cover and by soil moisture. Mulch tillage can lead to cooler temperatures because of the residue left on the soil surface. Removing residue from row areas and choosing varieties that tolerate cold and have early seedling vigour will overcome this problem.

RESIDUE MANAGEMENT

Mulch tillage is one of the best means to manage residue to benefit the soil, while saving time and fuel. When you work the residue into the top inches of the soil you speed up the breakdown of residue to humus. Also, because the soil is being worked, mulch tillage will help soil to warm and dry more quickly in the spring.

Equipment may have to be modified to handle the increased residue. See the table on page 20 to know the amount of residue you'll be working with in your system. In a mulch till system, planting equipment may have trouble cutting through residue because the soil is loose underneath. Proper changes to equipment can overcome this. See the section on equipment for ideas. High residue levels can be reduced through choice of equipment, the number of trips over a field and by including low residue crops such as soybeans in your crop rotation. Aim for 30 to 60% residue at planting.



Changes from Conventional System

- **Adjust harvest equipment to spread straw and chaff evenly.**
- **After planting, 30-40% of the soil surface will be covered with residue.**
- **If using rotary till or plain chisel equipment, chop corn stalks.**
- **Equipment must be changed to handle the increased surface residue.**

CROP ROTATION AND COVER CROPS

Crop rotations offer opportunities to break pest cycles, to control problem weeds, to improve soil structure, to increase crop yields and to save money on crop inputs such as fertilizer. Examples are:

- Legume forage crops offer savings in the nitrogen requirements of the next crop.
- Early cereal harvest allows an opportunity to control perennial weeds.
- Soybeans leave the soil in "mellow" condition, meaning it is easy to work and prepare for the next crop.
- Red clover or alfalfa may break up compacted layers if left for more than one year.

Changes from Conventional System

- **Crop rotation is essential to break pest cycles.**
- **Mulch tillage works with all crops in the rotation. Perennial forages should be chemically killed to avoid regrowth problems.**
- **Heavy residue crops, such as corn, must be chopped, either with the tillage implement or in a separate pass.**

TILLAGE OPTIONS – MULCH TILLAGE

Alfalfa or red clover in the rotation will improve soil structure and help break pest cycles. Also a legume will provide nitrogen to the next crop.

When planning a crop rotation, consider the following factors;

- ▶Livestock needs.
- ▶Equipment.
- ▶Economics.
- ▶Soil and climate.
- ▶Other crops in the rotation.
- ▶Amount of residue left from the crop.

There is no doubt that the best rotations are forage-based. In a mulch till system, surface residue will protect summer-seeded forages from erosion and catch snow for winter protection. For red clover-based forages/cover crops, frost seeding (broadcasting seed on frozen ground in the spring) works well. Residue acts as a mulch, keeping moisture close to the seed. Management of forages is similar to a conventional system.

COVER CROPS

Consider cover crops as part of the rotation when working in a mulch tillage system. Look at the type of crop, how it will be controlled (winter killed vs. chemical killed), and the amount of residue it will leave. Usually, it is best to use chemicals to kill a legume cover crop in the fall to make sure it is dead in the spring. Don't rely on tillage to kill the crop.

Some cover crops such as red clover leave a lot of residue on the surface. It may be best to work the ground in the fall to help dry the soil in the spring. In the spring, be prepared to kill some cover crops early. For example, rye should be killed early so it doesn't rob moisture from the next crop. In addition, early killed rye will not leave as much residue, making it easier to handle.

Cover crops such as red clover help protect the soil from water erosion during the winter and early spring months.

TILLAGE OPTIONS – MULCH TILLAGE

TILLAGE AND CROP ROTATIONS

When a change is made from a conventional system to mulch tillage, a chain reaction is set in motion which will affect your entire management system. Crops which leave little residue, such as beans or cereal with the straw removed, are relatively unaffected by the change as long as they are rotated with another crop. However, high-residue crops, such as corn or alfalfa, need more attention in a mulch tillage system.

Corn stalks can be easily disced or chiselled if the chisel plow is equipped with a gang of coulters or discs to slice through the stalks to prevent plugging. If your chisel plow does not have this feature, you may have to make an extra pass with a stalk chopper before tillage to break the residue into small pieces that won't interfere with other tillage passes. Because the corn residue is not buried, but mixed into the surface layer, it should be followed by a crop other than corn in the rotation.

Alfalfa and clover may not be completely killed by chiselling because some ground may not be sufficiently disturbed. It is better to spray the forage prior to tillage to get a good kill. Long-established alfalfa will probably have some quackgrass in it, so spray it with glyphosate to kill both. On clover, 2,4-D is a better choice to kill the legume. If you are farming lighter soils such as sands or loams, tillage can be delayed till spring without hurting yields. The untouched residue protects soils over winter.

NUTRIENT MANAGEMENT

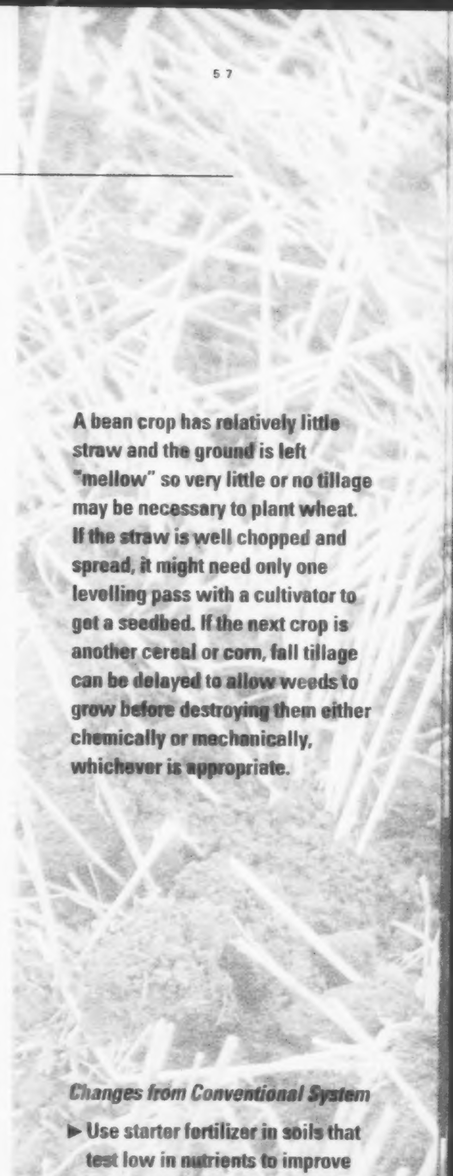
Test your soils before applying any nutrients. For more information, see page 27.

PLACEMENT

Placement is most critical when soil fertility is low. If soil fertility is high, there is less response to fertilizer placement. For this reason, start mulch tillage on fields which have tested medium to high for nutrients. Once you are comfortable with a system, and have learned to work with residue and made the necessary adjustments to your equipment, you may want to start experimenting with fertilizer placement if fertilizer is required.

Because soils in mulch till systems tend to be a little cooler and wetter than in conventional systems, there may be a benefit to using starter fertilizer.

The remaining fertilizer can be broadcast and incorporated with secondary tillage passes as in the moldboard system. Rates of application depend on the soil test. Nitrogen fertilizer must be injected or incorporated into soil.



A bean crop has relatively little straw and the ground is left "mellow" so very little or no tillage may be necessary to plant wheat. If the straw is well chopped and spread, it might need only one levelling pass with a cultivator to get a seedbed. If the next crop is another cereal or corn, fall tillage can be delayed to allow weeds to grow before destroying them either chemically or mechanically, whichever is appropriate.

Changes from Conventional System

- **Use starter fertilizer in soils that test low in nutrients to improve growth in cooler soil conditions.**
- **Nitrogen is best injected or worked in immediately.**
- **Liquid manure can be incorporated with a disc or chisel plow. Twisted shovels on the chisel plow will give better soil mixing than sweep teeth. With sweeps, too much manure tends to stay on the surface.**
- **Solid manure may be difficult to work in if it is spread too thickly.**

TILLAGE OPTIONS – MULCH TILLAGE

Photo courtesy of Loyal Equipment Ltd.

Manure should be injected where there is high residue.

Changes from Conventional System

- ▶ **Rotation is more important.**
- ▶ **Insect and disease types will be different but will not cause more problems if managed properly. Scout fields to watch for new problems.**

MANURE

Manure is both a fertilizer resource and a source of pollution. As a fertilizer, it contains nitrogen, phosphorus and potassium. It is also a good source of micronutrients and organic matter. For more information on nutrient values in manure, see the Livestock and Poultry Waste Management booklet.

Manure nutrients are preserved if manure is worked in within several hours of application. Incorporation also reduces the risk of rainfall washing manure off the field. Liquid manure can be incorporated with a disc or a chisel plow. The twisted shovel on a chisel plow does a better mixing job than the sweep. If the sweep is preferred for your soil type, consider a combination tooth (sweep and twisted shovel) to get the advantages of each. Mounting both sets will require more horsepower as more soil is being moved.

A thick layer of solid manure on top of residue can make it difficult for the chisel or disc to penetrate the soil. Make sure solid manure is spread evenly and only to the thickness that your tillage equipment can handle.

PEST MANAGEMENT

CROP DISEASES

Mulch tillage affects plant diseases directly and indirectly. Surface residue provides food and shelter for many types of disease organisms. For example, fusarium is of great concern to wheat and corn producers, particularly if they also feed hogs. In a mulch tillage system, avoid planting wheat after corn to overcome the potential problem of fusarium.

Crop rotation is the most cost-efficient means of reducing disease. The disease cycle is broken by planting a non-susceptible crop into the residue of a host crop. The longer the break between similar crops, the less opportunity for disease to get established.

Another way of reducing potential problems is to plant disease-resistant varieties. OMAF Publication 296 provides information on hybrids and varieties and their resistance to various diseases.

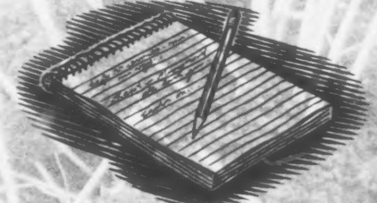
TILLAGE OPTIONS – MULCH TILLAGE

INSECTS AND SLUGS

Insects and other pest numbers may increase if there are a lot of weeds in the field. Weeds can act as a food source or an egg-laying location for pests. While the insect populations will be reduced by tillage, make sure that all vegetation is dead at planting time. Modify planting equipment to move residue away from the row area so young seedlings have a good chance to get established without pressure from insects and slugs.

Crop rotation offers the best control of pests. Different crop sequences will help break insect cycles.

Crop scouting on a regular basis will keep you aware of the type and extent of insect damage and help you plan for the next crop.



WEEDS

Changing tillage means changing your approach to weed control. Tillage buries weed seeds at different depths so they tend to germinate in flushes. An even flush is easiest to control but does not happen in mulch tillage conditions. Scout your fields and plan your spray program for the weeds that you have in your fields.

For the first few years, while you are learning the system, apply pre-plant, incorporated herbicides at the higher rate recommended for your soil type. If large amounts of crop residue interfere with good mixing action of the soil, consider using pre-emergent or post-emergent herbicides instead. These should be applied at normal rates.

Successful weed control depends on good crop management practices. Timely planting, good populations and fertility allow the crop to compete with weeds.

OMAF Publication 75 provides recommendations for appropriate herbicides and their rates of application.

Herbicide programs will change in a mulch till system. Consider using pre-emergent or post-emergent herbicides.

TILLAGE OPTIONS – MULCH TILLAGE

Changes from Conventional System

- **Secondary tillage and planting equipment need to have better clearance capacity.**
- **Planting equipment may need to be fitted with coulters and trash whippers to move residue out of the row area.**
- **Combine should be equipped with good straw and chaff spreaders.**
- **Chisel plows, discs and rotary tillage equipment are used for primary tillage.**

EQUIPMENT

Mulch tillage calls for modifications to all production equipment, including harvesting, tillage and planting equipment.

Choosing the right tool for soil conditions and amounts of residue is a high priority. When the primary tillage implement is changed, it sets off a chain reaction through the whole system. As more residue is left on the surface, secondary tillage implements may have to be adjusted or traded in for better clearance tools. Planting equipment may not be able to handle the high residue conditions left by mulch tillage, so you may have to add weights, heavy down-pressure springs, coulters, trash whippers, etc. If your planter is very light, it may not have the frame strength for modifications. Be prepared for changes throughout the system.

Mulch tillage can be achieved with many different tillage tools that leave various amounts of residue.

CHISEL PLOWS

Chisel plows are used for primary tillage. There are several types available. The coulter-chisel plow is the most common in southern Ontario. It combines a gang of discs or coulters in front of the chisel teeth to work in all residue conditions. The cutting action of the coulters/discs is necessary for handling corn stalks. This makes it easier for secondary tillage. After one pass, 30 to 75% of the residue is left.

The plows are solidly constructed with high clearance and shanks spaced 30 to 40 centimetres (12 to 16 inches) apart. This usually prevents plugging but in high residue or wet conditions, it can still be a problem. Spring-mounted chisel shanks vibrate and shed residue better than rigid shanks. They also last longer in stonier soils.

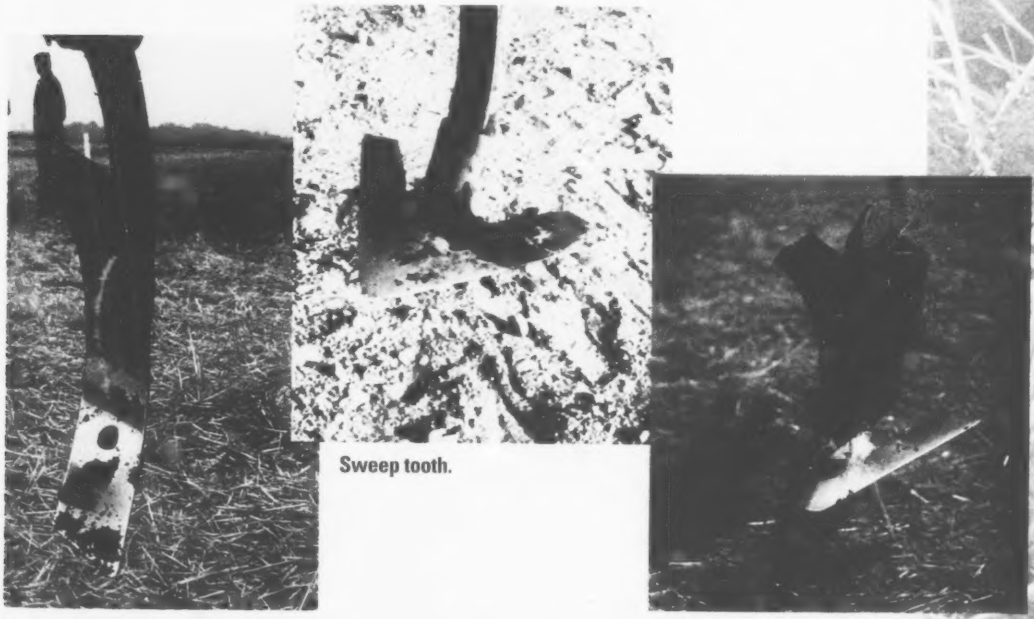
There are several types of chisel plows. This is referred to as a chisel plow with no disc/coulters on the front.

This coulter-chisel plow has a gang of coulters ahead of the chisel teeth.

TILLAGE OPTIONS – MULCH TILLAGE

Chisel Teeth

Chisel plows can be fitted with straight points, twisted shovels or sweeps in a variety of widths. Narrow points are only suitable for sandy soils, while twisted shovels which leave 28 to 40% residue cover are ideal for medium-textured soils such as loams and silt loams. Heavier soils such as silty clay loams or clay loams respond best to 40 to 45 centimetre (16 to 18 inch) sweeps; these give the best shattering action on these soils. The sweeps leave 40 to 60% of the residue on the soil surface after one pass and work all the soil the width of the machine. Only one pass is needed as each subsequent pass reduces the amount of residue. A sweep and twisted shovel can be mounted together on the shank. This is done to get the full shattering effect of the sweep and to incorporate more residue with the twisted shovel.



Sweep tooth.

Twisted shovel.

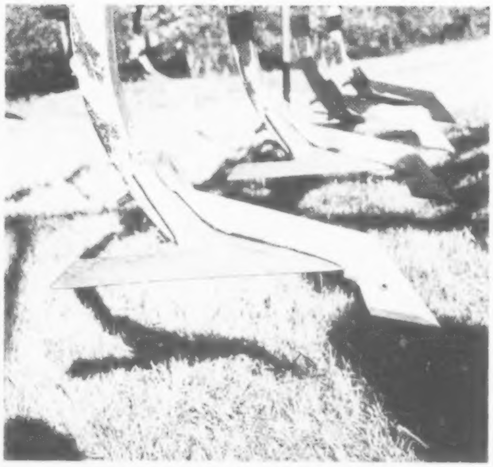
Combination twisted shovel/sweep tooth.

Chisel plows can be fit with different types of points.

CHISEL TEETH SELECTION

TYPE OF TOOTH	HP/SHANK	SOIL TYPE	RESULTS	% RESIDUE ON SURFACE*
STRAIGHT POINT	12 - 15	Best in light soils	Minimum incorporation of residue. Not all the soil is worked.	35 - 50
TWISTED SHOVEL	15 - 20	Sand to silt loam	Leaves soil surface ridged. Not all the soil is worked.	28 - 40
SWEEP	20	All types	Leaves most residue on the surface. Soil surface is relatively smooth. All of the soil is worked.	40 - 60
COMBINATION OF SWEEP AND SHOVEL	15 - 20	All types	Incorporates residue and works all the soil.	30 - 50

*Lower number for low residue crops such as soybeans. High number for high residue crops such as corn and cereals. If using a chisel plow without coulters/discs, residue levels will be five percent higher.



A deep banding tip on the sweep may help the chisel plow penetrate compacted, poorly structured soil.

Soil Penetration

In compacted, poorly-structured soils, you may have a problem getting the chisel plow to penetrate the ground. To overcome this, two options are available:

Add a deep banding tip (eg. Agri-Tech hardened point)

- ► To the end of sweep point
- ► To assist in penetration of soil
- ► To reduce wear of sweep

Use straight points on front shanks for soil penetration

- ► Follow with sweeps or twisted shovel points on back shanks
- ► Make sure soil conditions are right

TILLAGE OPTIONS – MULCH TILLAGE

TYPE OF POINT	[illegible]	SOIL TYPE	RESULTS	% RESIDUE ON SURFACE*
[illegible]	12 - 15	Best in light soils	Minimum incorporation of residue. Not all the soil is worked.	35 - 50
[illegible]	[illegible]	Sand to silt loam	Leaves soil surface ridged. Not all the soil is worked.	28 - 40
[illegible]	20	All types	Leaves most residue on the surface. Soil surface is relatively smooth. All of the soil is worked.	40 - 60
[illegible]	[illegible]	All types	Incorporates residue and works all the soil.	30 - 50

* Lower number for low residue crops such as soybeans. High number for high residue crops such as corn and cereals. If using a chisel plow without coulters/discs, residue levels will be five percent higher.

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- ►To the end of sweep point.
- ►To assist in penetration of soil.
- ►To reduce wear of sweep.

Use straight points on front shanks for soil penetration

- ►Follow with sweeps or twisted shovels on rear shanks.
- ►Make sure soil conditions are dry.

TILLAGE OPTIONS – MULCH TILLAGE

Set up and Operation

When using twisted shovels, it is important to set them up so there are equal numbers of left and right shovels. If there are three rows of shanks, the first row of shovels should all turn the soil in the same direction, the second in the opposite direction and the third would be split, turning soil towards the centre of the plow. Left and right shovels are turned towards each other to form ridges. A combination of sweeps and shovels may be used. The most common is to have twisted shovels on the front row(s) and sweeps on the back row.

Chisels must be used when the soil is dry for proper shattering action.

Discs or coulters on the front of chisel plows are set to run just deep enough to cut the residue. Discs may be set deeper to work in more residue. In order of ease of adjustment, depth may be controlled by:

- ►Hydraulics.
- ►A ratchet.
- ►Nut and bolt arrangement.

On variable soils, the hydraulic system is useful. The choice between discs or coulters depends on the amount of residue to be worked into soil. Coulters incorporate less than discs. Discs may be adjusted to different angles. The straighter the angle, the less residue that will be incorporated.

For proper shattering action, chisel plows must run at speeds between 8 and 11 km/h (five and seven miles per hour) and on soils dry at working depth. The operating depth for the chisel plow with twisted shovels is 15 to 20 centimetres (six to eight inches) and 10 to 15 centimetres (four to six inches) for sweeps. Tillage is usually done at an angle to old crop rows.

In wet conditions, the chisel plow is less effective at soil shattering and can cause soil smearing. A moldboard plow works better on clay and clay loam soils. In wet falls, chisels may not work adequately on medium-textured soils.

Sometimes, after chisel plowing with twisted shovels ridges are left which cause problems. Uneven soil drying occurs which may lead to uneven emergence across a field. This problem can be overcome by using sweeps on the back row of the chisel plow or adding a levelling device (such as a buster bar harrow) on the back to level the ridges.

A buster bar can be added to the back of a chisel plow to help level the ridges.

Before buying or even borrowing a chisel plow, make sure you have a tractor with enough horsepower to pull it in your fields. You will need roughly 15 horsepower per shank. For example, a seven-shank chisel plow requires a 105 horsepower tractor. On heavier soils such as clay loams, up to 20 horsepower per shank will be needed.

TILLAGE OPTIONS – MULCH TILLAGE

DISCS

Discs are used for both primary and secondary tillage. Residue is mixed into the soil about three-quarters of the depth of tillage. It will leave 30 to 70% of residue after one pass. It breaks up the residue and loosens the soil surface. Use of the disc in wet soil conditions can lead to compaction at the tillage depth. This is caused by pressure exerted by the curvature of the blade. This problem can be minimized by varying the depth of tillage every year, or by alternating primary tillage tools every few years. If poor root growth or surface ponding is seen after a few years of discing, using a chisel or mold-board plow to a depth of three or five centimetres (one or two inches) below discing depth, will usually ease the problem. If the problem is back in a year or two, consider a permanent change to a chisel plow.

The offset disc will leave more residue on the soil surface than a tandem disc.

Offset vs. Tandem Disc

The offset disc gets better penetration and handles residue more easily than the tandem disc. Because of its heavy frame and larger blades, the offset disc can be used on more soil types and in almost all residue conditions. The heavy frame is needed so that extra weights can be attached for better penetration in hard ground. Tandem discs are usually only used for primary tillage on light soils and in cereal stubble. Only blades larger than 60 centimetres (24 inches) should be used for primary tillage.

Blade Selection and Spacing

A wide variety of blades are available with smooth or notched edges and a variety of thicknesses and sizes. Make sure you know what kind of blade you want before buying a disc. Changing blades is expensive and time-consuming. If possible, rent or borrow different types of discs to see how they perform on your soil before buying.

Notched blades help penetrate hard ground and work better in heavy residue situations. Because notched blades are more expensive than smooth ones and they wear faster, some producers use them only on the front gang and put smooth blades on the back.

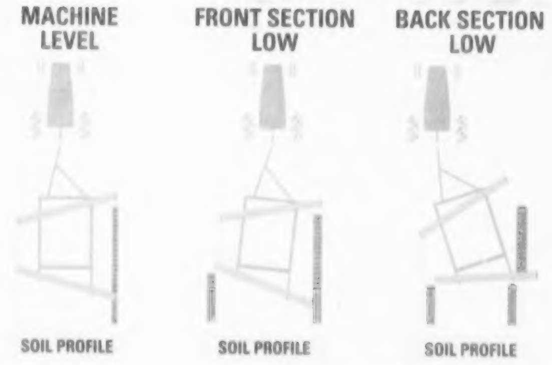
Compromise on blade spacing will be necessary if the disc is used for both primary and secondary tillage. Wider spacing 28 to 33 centimetres (11 to 13 inches) is preferred for primary tillage for better residue flow. Narrower spacing 23 to 28 centimetres (9 to 11 inches) is better for secondary tillage because this provides uniform incorporation of fertilizers and pesticides and the soil surface is left level. Some discs come with a wider spacing on the front gang and narrower spacing on the rear gang.

TILLAGE OPTIONS – MULCH TILLAGE

Set up and Operation

To get the best results, the disc should be operated at speeds of 6 to 10 k/m/h (four to six miles per hour) at a depth of 10 to 15 centimetres (four to six inches). Count on at least 14 HP per 30 centimetres (foot) of working width. As with the chisel plow, you may find that more horsepower is needed as the soil type gets heavier.

The most difficult aspect of working with discs is setting them so that they produce a level surface. A disc that is improperly set will leave trenches and hills at either edge. Always check the disc for level operation from front to back first, then from side to side. This is done by running the disc in the field for about a hundred metres (300 feet) at working speed and judging the results. The diagram shows the results if the disc is levelled front to back, if the front is set too low or if the back is set too low. When the disc is properly adjusted, the back section should be 3 to 5 centimetres (one to two inches) lower than the front. The sections can be raised or lowered using manual or hydraulic devices. After making adjustments, do another test strip to check results. Repeat until the soil surface is left smooth.



Levelling the offset disc.

Once the machine is levelled front to back, check for side-to-side level operation. The soil should be worked to the same depth on either side. Depth control is determined by the wheels of the implement, so make sure tires are properly inflated and on the ground when checking depth.

ROTARY TILL IMPLEMENTS

A rotary till implement (eg. Aerway) is a primary/secondary mulch tillage implement you can use on lighter soils. Its success has been limited on heavier soils due to problems getting adequate penetration. It is a single tool bar equipped with non-powered rotating knives. The frame is heavy enough that extra weights can be attached. This implement can be used for one pass tillage, although it is more common to make two passes. It will leave considerable residue on the soil, while leaving the surface relatively level. Material which survives the winter should be killed, as rotary tillage may not destroy all plants.

Rotary till implements will leave a high percentage of crop residue on the soil surface.

SECONDARY TILLAGE

Secondary tillage should be kept to a minimum to conserve residue. It should be sufficient to mix in fertilizers, work in pre-plant herbicides and level the surface. Heavy residue, like corn stalks, can cause plugging problems. Field cultivators may need to have a few tines removed and others re-spaced for better residue flow. An overall spacing of 13 to 15 centimetres (five to six inches) between tines should give the best compromise between residue flow and a level seed-bed. It may be necessary to trade in the S-tine cultivator for a high clearance C-shank cultivator. C-shank cultivator frames are stretched and raised to make residue flow easier.

Secondary tillage should be kept to a minimum. Consider using a once over implement such as pictured to eliminate trips over the field.

TILLAGE OPTIONS – MULCH TILLAGE

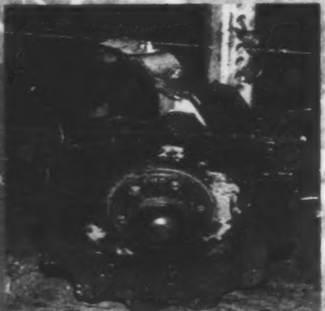
The offset double disc opener is the preferred opener for planters in high residue situations.

PLANTING EQUIPMENT

When planting into tilled soil, aim for residue levels between 30 and 40% after planting. To get uniform stands in mulch till fields, planters must:

- ▶Clear or cut residue ahead of the seed opener.
- ▶Open a narrow trench in firm, moist soil.
- ▶Maintain accurate depth control and seed placement.
- ▶Press seed into the soil, cover and firm soil over the seed.

Planting equipment may need modifications in high-residue situations. If you are in the market for a new planter, look into some of the conservation models which have heavier frames and down pressure springs for better soil penetration, coulters to remove residue, offset double disc seed openers, gauge wheels at the seed opener for better depth control and press wheels for improved seed trench closing.



Notched trash whippers handle high residue situations easily and move the residue off the row area.

Seed Openers

The preferred type of seed opener for planters is the offset double disc opener. Offset double disc openers can slice through residue and reduce plugging problems. They also offer better depth control as they do not ride up and over residue. Drills have three options for seed openers: single coulter with shoe, offset double disc and double disc. All work well in high residue situations.

Coulters

Chisels and discs leave the soil soft, so that coulters which should slice residue may instead, push it into the ground. Rather than planting into soil you would be dropping seed into a fold of residue (hairpinning). There will be no soil-seed contact and more chance of toxic effects from residue. The ripple coulter does the best job of slicing through residue. Planters may need a coulter and a trash whipper mounted in front of seed openers for proper seed placement in heavy residue.

Smooth-edged trash whippers are another option. Trash whippers must be set properly to move residue, not soil from the row area.

Trash Whippers

Trash whippers are a set of discs slightly offset, which whisk larger pieces of crop residue and soil clumps out of the row area. There are many types and styles available: smooth-edged, notched or toothed and a variety of sizes. Preferences depend on individual tastes. All require care in setting at the correct height to move residue, not soil.

The more rough and uneven the ground is, the more difficult it is to set the trash whippers at a height where they remove enough residue without cutting a trench in the seedrow. Trash whippers should be mounted on the seed unit for better depth control.

TILLAGE OPTIONS – MULCH TILLAGE

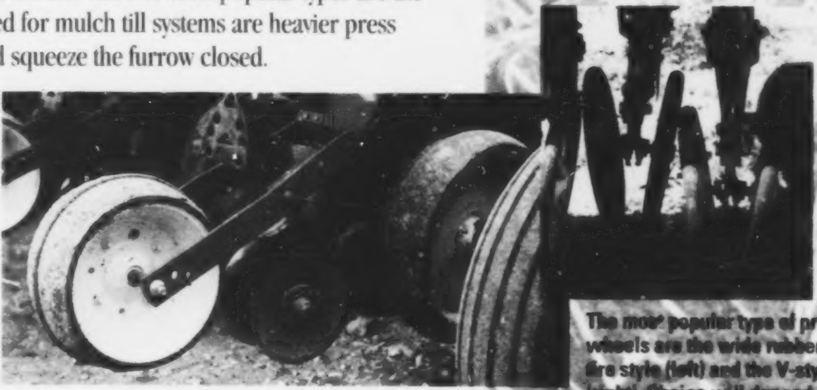
Press Wheels

Arguments abound about which configuration is best. The two most popular types are the V-style and the rubber-tire style. What you need for mulch till systems are heavier press wheels that have narrow points of contact and squeeze the furrow closed.

Press wheel choice will depend on your soil type and moisture conditions at seeding. Press wheels should:

- ▶Cover the seed with soil not residue.
- ▶Firm but not compact soil around the seed.
- ▶Avoid crusting after planting.

Time spent adjusting press wheels is time well spent.



The most popular type of press wheels are the wide rubber tire style (left) and the V-style (right). Choice will depend on your soil and planting conditions.

Seeding Rate

Seeding rates are not different from a conventional system. In rougher conditions, reduce speeds to maintain depth and get adequate seed coverage. Check your tire pressure to reduce slippage, which also affects your seeding rate! Monitor plant populations to ensure seeding rate was adequate. The planter must be adjusted to maintain the correct seeding rate.

Planter Set-up/Field Operation

In high residue situations, it becomes important to check the planter in the field when it is actually operating. Check:

- ▶Seeds are being placed at the proper depth and spacing.
- ▶Press wheels are closing the seed trench properly.
- ▶Trash whippers are set properly to move residue (not soil) from the row area.
- ▶Coulters are cutting residue, not pushing it into the ground.
- ▶Residue guards are in place to protect moving chains, etc.

With proper planter set-up in a mulch till system you should have an even stand of healthy soybeans.

TILLAGE OPTIONS – MULCH TILLAGE

HARVEST EQUIPMENT

The importance of well-spread residue is particularly important. Combines should be equipped with chaff and straw spreaders capable of spreading residue evenly over the full working width of the combine. This is the first step in any mulch tillage program.

In a mulch till system it is important that residue and chaff are spread evenly across the harvest width.

Best Management Practices for Mulch Tillage

- **Match tillage implements to tractor horsepower. It's better to use a smaller implement on a larger tractor than the other way around.**
- **Only till when the soil conditions are right. Avoid wet fields.**
- **Only till when necessary. No-till planting wheat into bean stubble may be an option.**
- **Till across slopes to cut erosion losses. Chisels and discs are quite capable of working on gentle curves, but do not make tight turns with the implement still in the ground.**
- **Set coulters on chisels just deep enough to cut residue to avoid excessive wear.**
- **Chisel plows and discs perform better in corn residue if the field is worked at a slight angle to the old rows.**
- **Make sure that right and left throwing twisted shovels are alternated on chisels.**
- **Both chisels and discs should be checked for level operation.**

There is no doubt that the cost of modifying equipment or, in some cases, replacing equipment, will make the change to mulch tillage more expensive. However, there are savings in reduced labour and fuel, not to mention soil saved once your program is running.

GETTING STARTED

Select the most appropriate tillage system for you. As you change systems, other management aspects will change as well. Consider the following points as you get started.

Chisel plow at a slight angle to old corn rows to prevent plugging problems.

Soil type

The lighter your soil, the more options you have. No-till or mulch till will work well. On poorly-drained clay and clay loam soils, the moldboard plow may be the best option.

TILLAGE OPTIONS – MULCH TILLAGE

Drainage

If you are considering mulch tillage, improve drainage first. Residue on the soil surface will slow the drying process.

Drainage is an important component in a mulch till system. Make sure wet fields are tiled first before starting mulch tillage.

Erosion potential

Long, steep slopes have more erosion problems and require more drastic changes in both cropping and tillage. Complex slopes are difficult to manage with just cropping changes. Tilling on the contour or cross-slope is easier with chisel plows or offset discs than with the moldboard plow. Secondary tillage and planting can also be done cross-slope if the slope is simple. With complex slopes, it might be more effective if primary tillage is done on the contour and secondary tillage and planting are done the length of the field. Protect soil through the winter and early spring by leaving residue on the soil surface or planting cover crops.

Leaving residue on the soil surface will help prevent soil erosion. Know how much residue you will be working with so you can modify your cropping program as needed.

Cropping program

What crops will you be working with? How much residue will they generate? Crop rotation is more critical with mulch tillage because it helps control weeds, insects and diseases. Crop sequence is also important as problems may arise when some crops follow each other such as corn and wheat.

Weed pressure

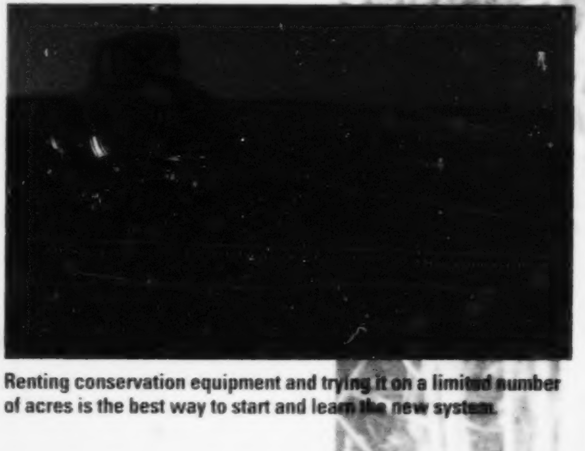
Know what weeds to expect in your fields and how to control them. Walk your fields regularly to see what is happening. Be prepared to use the rotation to advantage in controlling perennial weeds such as milkweed and quackgrass. Your options for chemical weed control may be slightly different than with a conventional system so be prepared for change.

Available equipment

Assess your tillage and planting equipment and its ability to handle residue. Plan modifications, adjustments and trades in advance.

Management ability

Talk to successful mulch tillage farmers and attend conservation meetings. By anticipating problems, you can be prepared with alternative solutions. Be willing to make changes in your system. Keep an open mind, use some patience and you will be successful.



Renting conservation equipment and trying it on a limited number of acres is the best way to start and learn the new system.

TILLAGE OPTIONS – MULCH TILLAGE

IMPLEMENTING A MULCH TILLAGE SYSTEM– A FIVE-YEAR PLAN

The following is a plan to implement a mulch tillage system over a period of five years. You may be able to speed up or slow down the process depending on your farm situation.

YEAR 1

- ▸ Identify your soil types from a soil map available at the OMAF office.
- ▸ Make a rough map of your farm, locating buildings, fencelines, woodlots, wet areas and slopes. Make several copies of the map.
- ▸ Keep field-by-field records.
- ▸ Scout your fields, noting locations of weed problems and identifying weed species. If you can not identify a weed, take it to the OMAF office for identification.
- ▸ Test the soil in your fields if you have not done so in the past three years.
- ▸ Plan to correct any drainage problems before starting a mulch tillage program.
- ▸ Outline your crop rotation on paper. Plan to start your system after a bean or after a cereal crop, if straw is removed.
- ▸ Check tine spacing of your secondary tillage equipment for proper residue flow. Tines should be about 15 centimetres (six inches) apart.
- ▸ Locate mulch tillage equipment available for rent in your area, including secondary tillage equipment. Look for a variety of types and configurations to experiment with.
- ▸ Evaluate your planter and drill's ability to operate in residue. Locate conservation planters and drills available for rent.
- ▸ Read up on mulch tillage in farm papers, OMAF factsheets, attend soil and crop project tours and consult with extension staff.
- ▸ Talk to successful mulch tillage farmers, find out what similarities you have and what your differences are. Choose farmers with similar soil conditions if possible. See what mistakes they made and learn from their experience.

Scouting is very important to keep ahead of the changes that occur in a mulch till cropping system and will help you keep accurate records.

TILLAGE OPTIONS – MULCH TILLAGE

YEAR 2
- Fertilize according to soil test recommendations.
- Keep up field records of problem areas, weeds and other pests. Plan your control options for all crops in your rotation.
- Adjust the straw spreader on your harvest equipment or find a custom operator who has a good straw spreader on his.
- Start with a small area of 2 to 4 ha (five to ten acres) with a rented piece of equipment.
- Work the chisel or disc across the slope, regardless of row direction to prevent water running down the furrows.

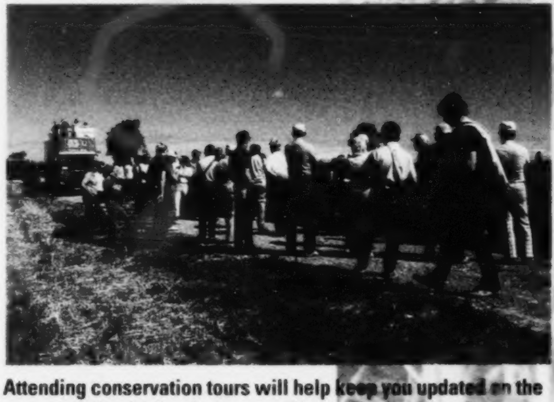
YEAR 3
- Continue to keep field records and evaluate crop progress on small plots.
- Secondary tillage and planting should be timed according to your soil conditions, not according to what your neighbours are doing. Working or planting the ground when it is too wet will result in a cloddy seedbed and a reduced stand. You may plant a day or two later than you would under conventional systems. Be patient.
- Expand the acreage worked to include more types of residue.
- Try different teeth on the chisel plow or a combination of twisted shovels and sweeps to see what works best for your soil and residue type.

YEAR 4
- Continue monitoring crop progress and keeping field records.
- Evaluate weed control and pest management. Get advice if necessary to make changes.
- Prepare a budget for buying conservation equipment. Find out the value of equipment to be traded in. Check the prices of available equipment. You may continue renting for a few years.
- Make needed adjustments to planting equipment to handle more residue.
- If all your equipment will handle residue, mulch till corn ground.

YEAR 5
- Evaluate program and make changes as necessary.
- Assess your need for new equipment and make the necessary purchases. Modify existing equipment if possible.
- Continue to update your crop and pest management skills.
- Keep field records up-to-date.

By following this plan, keeping good records and monitoring your progress you should be able to implement mulch tillage successfully.

Taking yields on your trial fields will help you make decisions on changes needed in the cropping program.



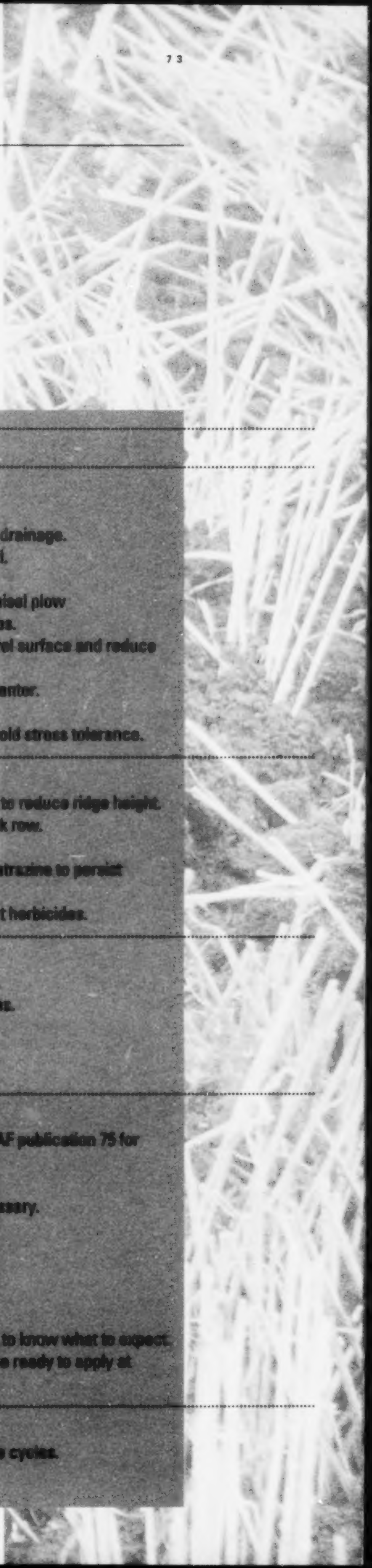
Attending conservation tours will help keep you updated on the newest technologies that are working at the farm level.

TILLAGE OPTIONS – MULCH TILLAGE

TROUBLE SHOOTING

PROBLEM	CAUSE	SOLUTION
Increased run-off	•Tilling up and down hill creates channels for water	•Work the field across the slope so water "walks" across the slope rather than "runs" down it.
Surface ponding	•Compaction/poor soil structure	•Improve rotation. Use cover crops including legumes and add manure to improve soil structure. Avoid tilling and manure applications when soil is wet.
Uneven chisel plow penetration	•Plow not level •Dull or worn points •Soil too hard for sweeps	•Check for level operation front to back and side-to-side. •Check and replace or sharpen points. •Wait for a light rain to soften the soil (Do not till if wet). Put points on front row to break hard soil, leave sweeps on rest.
	•Not enough horsepower for proper penetration depth	•Remove one or two shanks from each side to reduce working width. Use higher powered tractor.
Residue plugging chisel or disc	•Poor residue distribution from combine	•Adjust or buy add-on spreader.
	•Too much straw	•Bale cereal straw. Set cutting head higher. Rotate high residue crops with low residue crops (i.e. corn, beans).
	•Coulters not turning	•Set lower to cut deeper into soil. Lubricate or replace bearings.
	•Coulters set too deep	•Set coulter shallower to slice residue.
	•Twisted shovels arranged incorrectly	•Arrange so all shovels on the front row throw in one direction. All in the middle row throw in the opposite direction and the third row is split so all throw to the centre.
	•Residue too wet	•Wait for drying or frost.
Residue plugging cultivator	•Inadequate clearance in cultivator frame	•Remove a few tines and re-space the rest to ease residue flow. Rent/borrow/buy high clearance cultivator. Exchange sweeps for twisted shovels on chisel to bury more residue.
Residue plugging planting equipment	•Inadequate clearance for larger pieces of residue.	•Add coulters on planter to slice residue. Add trash whippers to deflect residue out of the row area. Drills should be equipped with staggered seed units for better residue flow. Add coulters/discs on chisel plow to cut residue into smaller pieces.
[illegible]	•[illegible] seed openers	•Check for wear and replace if needed.
	•[illegible]	•Make sure coulters are sharp and able to cut residue. Add trashwhippers to deflect residue.
	•[illegible]	•Adjust down pressure on drive wheel.

TILLAGE OPTIONS – MULCH TILLAGE



TROUBLE SHOOTING CONTINUED

PROBLEM	CAUSE	SOLUTION
Poor germination	•Rotting or diseased seed	•Use seed treatment. Use a crop rotation. If soil too wet, plant shallower and improve drainage.
	•Planted too shallow	•Adjust seeding depth to place into moist soil.
	•Cloddy seedbed	•Soil worked too wet; delay tillage. Exchange twisted shovels for sweeps on chisel plow for smoother surface and smaller aggregates. Add levelling harrow to back of chisel to level surface and reduce moisture variation.
	•Cold seedbed	•Too much residue, add trash whippers to planter. Delay planting a day or two. Change to a hybrid or variety with greater cold stress tolerance.
Uneven emergence	•Cloddy seedbed	•See above under poor germination.
	•Uneven moisture due to ridges formed by twisted shovels	•Add levelling harrow to back of chisel plow to reduce ridge height. Switch to all sweeps or add sweeps on back row.
	•Herbicide carryover	•Less soil mixing may cause herbicides like atrazine to persist and damage the next crop. Use lower rates or change to less persistent herbicides.
Weed escapes	•Inadequate herbicide contact with soil	•Incorporate with two passes. Increase water volume for better coverage.
	•Perennial rhizomes less disturbed	•Identify weeds and treat at appropriate times.
	•Second flush of weeds	•Inter-row cultivate row crops. Apply post-emergent spray if economical.
Poor weed control	•Use of inappropriate herbicide	•Identify weeds present. Consult a Soil and Crop Advisor and/or OMAF publication 75 for best control options.
	•Inaccurate rate of application	•Calibrate your sprayer. Check nozzles for wear and replace if necessary. Re-check rates specific to your soil type. Spray only when chances of wind or heavy rains are minimal. Maintain constant ground speed.
	•Weeds too large	•Scout your fields regularly. Keep field histories of weeds and diseases, to know what to expect. Plan herbicide treatments in advance and be ready to apply at the appropriate time.
Disease	•Susceptible varieties	•Use resistant varieties. Follow a crop rotation which breaks disease cycles.

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Poor seed placement	•Worn seed openers	•Check for wear and replace if needed.
	•Hairpinning	•Make sure coulters are sharp and able to cut residue. Add trashwhippers to deflect residue.
	•Skips or misses	•Adjust down pressure on drive wheel.

TROUBLE SHOOTING CONTINUED

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TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

No-till corn in soybean residue.

NO-TILL

The move to the no-till system is gaining popularity in North America. Farmers, who are concerned with soil and water quality, find no-till systems a profitable alternative. Three points describe no-till:

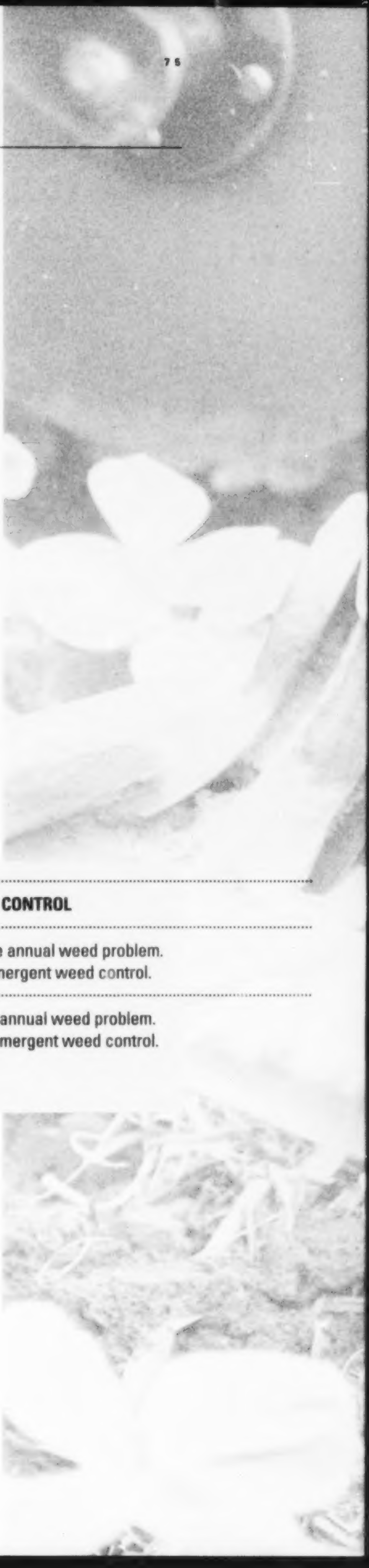
- Fields are no longer plowed.
- Plant residues remain on soil to protect it from erosion.
- During the planting operation, a narrow seedbed is prepared by the planter/drill to allow adequate seed and fertilizer placement.

RIDGE TILL

Ridge till is an alternative to no-till. It requires more initial effort and investment so consequently, is not adopted as readily. This system is more adaptable to poorly-drained soils than no-till. The same basic principles for no-till apply along with the following:

- A cultivator forms a ridge during early summer. The following year's crop is planted onto the ridge.
- Once established, the ridges are not removed.
- The establishment of permanent ridges means that traffic is limited to specific areas within the field. This reduces soil compaction in the root zone. However, it often requires wheel-spacing modifications to machinery.
- Weeds are controlled with a row crop cultivator which reduces the need for herbicides.
- At the present time, forage crops are not usually grown on ridges.

Ridge till soybeans into corn stalks.



TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

TRANSITION PHASE – GETTING FROM A TO B

Experienced no-till and ridge till farmers often talk of a transition period of three to five years before seeing the full benefits of the system. During this transition phase, a number of changes occur.

- ▸The soil structure will improve.
- ▸Residue management changes.
- ▸The type of pests and their control may change.
- ▸Equipment will change.
- ▸Crop rotations may change.
- ▸Nutrient management changes.

This is a period of adjustment for you and all the components of your cropping system. The following table illustrates one example.

POTENTIAL CHANGES OVER TIME – NO-TILL

	SOIL	PLANTER	ROTATION	WEED CONTROL
No-till start-up.	Poor structure Poor drainage.	Two coulters.	Continuous corn.	Severe annual weed problem. Pre-emergent weed control.
Changes after 3 years of no-till.	Improved structure and drainage.	Two coulters and a trash whipper.	Corn, soybeans and wheat.	Minor annual weed problem. Post-emergent weed control.

As soil structure changes, the soil will dry and warm up faster in the spring. This will, in turn, have an effect on planting dates. Satisfactory results may be experienced during the first year of no-till or ridge till if all the parts of the crop production system are considered.

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TILLAGE OPTIONS –
NO-TILL AND RIDGE TILL SYSTEMS

Soil Changes from Tillage Systems

- **Organic matter levels gradually increase at the surface.**
- **Soil structure will improve (better aeration, water movement and root growth).**
- **Soil will be firmer.**
- **Soil life will increase (more worms, insects, bacteria and fungi).**

Change varies because it depends on initial soil conditions and the crops being grown. For example, crop rotations which include cereal and forage crops show the quickest improvements because of their fibrous root systems.

SOIL MANAGEMENT

THE NATURAL CHOICE

No-till/ridge till farmers feel that their soil approaches the natural situation. To gain a better understanding of this environment, think about the Canadian forests. Tree leaves fall onto the soil surface to provide a permanent cover, so you rarely see erosion. Below the dead leaves exists a vast population of worms, fungi, bacteria and other soil life. This underground world decomposes leaf litter and helps feed the trees.

It may be difficult to relate forests to modern agricultural practices. But, what happens in a forest is similar to how no-till/ridge till farmers handle their land. They do not till fields and crop residue is left on the soil for protection. Beneath the residue, as in the forest, exists a healthy soil life.

Surface litter, as on a forest floor, encourages diverse soil life.

No-till fields provide the closest environment to the active forest.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

SOME SOILS ARE HARDER TO MANAGE

Fine sandy loams, silt loams and clays are trickier to manage in no-till/ridge till. They can be slower to dry under heavy residue. With time, the structure of these soils improves and timing of planting operations may change.

- Delays in planting may be necessary if soils are too wet.
- It's important not to wait too long to plant though, or clay soils will become too dry and hard.
- Spring soil conditions from year to year will differ requiring proper machinery selection and adjustment.
- Ridge tillage may help planting delays because of wet conditions. Ridges will dry out and warm up faster than non-ridged ground.

REDUCED SOIL COMPACTION

The risk of soil compaction can be reduced with no-till because the number of trips over a field is reduced. In ridge till, traffic is further limited to specific areas of the field.

SOIL LIFE

Residue on ridge till/no-till fields favours soil life which, in turn, improves soil structure, decomposition and the amount of air in the soil. Earthworms grind and mix residue placing it in a moist environment. Their excrement is more readily available to soil microbes. With a readily available food source, the soil microbes become more active and increase the rate of decomposition of residue.

Management Changes from Tillage Systems

- **Seedbed is prepared with very little tillage.**
- **Some soils may be slower to dry in the spring. Usually, this is a concern during the transition phase.**
- **Some soils may dry faster as soil structure improves.**

No-till planting of soybeans.

Piles of residue over earthworm holes.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Residue Changes from Tillage

- **30 to 80% of soil surface is covered with crop residue after planting.**
- **Residue may slow warming and drying of soil in the spring.**

RESIDUE MANAGEMENT

The most obvious concern for first-time no-till/ridge till farmers is residue. Residue is important and will not cause problems if managed properly.

Residue management is the heart of the no-till/ridge till system. All field operations – planting, fertilizing, inter-row cultivation, weed control and harvest – must be adapted. Managing crop residues prior to planting allows these operations to proceed more smoothly.

When residue remains on the soil, it acts as insulation. This slows the rate of soil warming during the day as well as the rate of cooling at night and may delay planting during the transition phase. Short rotations, earthworms and increased microbial activity will improve soil structure and drainage and help speed up soil warming.

The residue was spread evenly last fall and the field is ready to plant.

CHOPPING CROP RESIDUE

Farmers have different opinions about chopping residues. Some of these views seem contradictory but make sense when addressing the situation at hand.

ADVANTAGES	DISADVANTAGES
If stalks are chopped in ridge till, the tops of ridges will dry out and warm up more quickly allowing earlier seeding.	Chopping residue makes a thick mat which reduces soil warm-up. Dark soil absorbs more heat than light-coloured residue.
In warm locations, weeds may germinate more quickly allowing better burn-down treatments.	In ridge till corn-following-corn on heavy clay, chopped stalks accumulate in valleys.This may keep soil too wet and cause rutting.
In ridge till, chopping stalks will leave cleaner ridges for smooth planting. This may not be a concern for more experienced operators.	If land slopes, chopped residue in valleys may wash off during heavy rains and accumulate in low lying areas.
	Chopping uses fuel, wears out machinery and adds a pass over the field.

Leaving stocks unchopped offers the following advantages:

- Standing residue traps more snow and increases soil moisture reserves on lighter textured soils.
- Standing residue slows heat loss from cool air currents.

Management Changes from Tillage Systems

- **Residue must be spread evenly at harvest.**
- **Planting delays are possible during the transition phase.**
- **Field operations and equipment must change to accommodate surface residue.**

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

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TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

CROP ROTATIONS

Crop rotations are crucial to the success of reduced tillage systems. They help in residue management and are important for improving soil structure. Rotations also help break disease and insect cycles.

Corn on ridges following soybeans.

CROP SEQUENCES FOR RESIDUE MANAGEMENT

As mentioned, crop residues can slow the rate of soil drying. This does not necessarily delay planting.

Plant corn into soybean residue - soybeans leave little residue on the soil surface and what is there readily decomposes. If corn is planted in soybean residue, cold ground should not be a problem.

Plant soybeans into corn residue - soybeans are usually planted later than corn. This gives soil covered with corn residue enough time to warm up.

Plant corn or soybeans into cereal residue - cereals and forage crops have fibrous root systems which improve soil structure and drainage. Cereals are often underseeded with a cover crop such as red clover. In this case, a fall herbicide treatment reduces weed problems. Often, soils such as silt loams and clays with cereal residues are slow to dry and warm in the spring. In these soils, planting corn directly into cereal stubble has reduced yields.

No-till soybeans planted into corn residue.

There are three common solutions:

- ▸Use trash whippers or coulter tillage to help soil warm up.
- ▸Lightly till the residue.
- ▸Wait till spring to kill the underseeded crop as it will help dry the soil.

No-till soybeans in cereal residue.

[illegible]

The Following is an Example of a No-till Rotation for livestock operations:

YEAR 1 ▶ **Oats underseeded with alfalfa.**

YEAR 2 ▶ **Alfalfa.**

YEAR 3 ▶ **Alfalfa.**

YEAR 4 ▶ **Alfalfa.**
  ▶ **August 15th: inject liquid manure.**
  ▶ **September 15th: burn-down treatment.**

Year 5 ▶ **No-till corn silage.**
  ▶ **September: inject liquid manure + cover crop.**

YEAR 6 ▶ **No-till barley.**
  ▶ **June: broadcast cover crop.**
  ▶ **August: inject liquid manure.**

YEAR 7 ▶ **No-till grain corn.**

YEAR 8 ▶ **No-till soybeans.**

Start rotation over.

ROTATION EFFECT AND DISEASE PREVENTION

When a crop is planted into its own residues, yields go down. Researchers are not sure why. It may be a combination of factors including: pests, diseases and toxic effects of plant residues. Wheat residue seems to cause corn and soybeans to perform poorly on clay and silt loam soils in cold and in wet, early growing conditions.

Never plant wheat into wheat or corn residue - potential disease problems exists with wheat regardless of the tillage system employed. See the OMAF factsheet on Fusarium Head Blight. Excessive soil moisture and damp weather may increase disease risk. Large quantities of residue on the soil aggravate the problem but do not cause it.

COMMON CROP ROTATIONS

Without Forages

▶ Corn - Soybeans - Cereals underseeded with red clover.
▶ Corn - Soybeans.
▶ Soybeans - Cereals.

Edible beans may replace soybeans in any of the above.

With Forages

Harvesting forages during summer months takes labour away from row crop cultivation and manure applications. Change the timing of manure operations to August and September. Then, cover crops can tie up nutrients applied to the soil.

SUMMARY OF CROP ROTATIONS

CROP RESIDUE	**CROP TO BE PLANTED**			
	CORN	*SOYBEANS*	*WHEAT*	*FORAGES*
CORN	**Insect and disease problems**	Recommended	Avoid - disease potential is too great	Recommended
SOYBEANS	**Recommended**	Can work well but better to follow with a non-legume crop	Recommended	Usually works well but better to follow with a non legume crop
WHEAT	**Soils may be slow to dry**	Usually works well if wheat was not under seeded to red clover	Avoid as disease potential is too great	Recommended
FORAGES	**Usually works well but watch for slugs**	Can work well but better to follow with a non legume crop	Can be done as long as forage is killed completely before planting	Can be done if sod is completely killed (three weeks before planting)

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

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TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

NUTRIENT MANAGEMENT

The surface residue found in no-till/ridge till, combined with improved soil structure favours soil life that aids nutrient cycling.

NUTRIENT STRATIFICATION

The absence of tillage allows nutrients to accumulate in the top layers of soil. Nutrient levels below this layer tend to be lower than conventionally-tilled soils. No harmful effects on nutrient uptake and yield have been observed in 25 years of research.

NITROGEN

- ►Nitrogen applications on cereals are similar to the conventional system.
- ►Nitrogen for corn should be placed below the residue. Avoid broadcasting urea-based products.
- ►Many no-till farmers believe approximately 30 kilograms per hectare (27 lbs per acre) of nitrogen should be in the starter fertilizer. No yield benefits result, but early crop appearance is improved.
- ►Coulters are usually added to equipment to improve fertilizer placement.
- ►In ridge till, nitrogen is knifed into the ridge (stay away from corn roots) or in the valley. Liquid nitrogen can be dribbled behind the disc hillers on the cultivator where it will be covered with soil thrown by the sweeps.

PHOSPHORUS

- ►Apply phosphorus in a band at planting time to meet soil test requirements.

POTASSIUM

- ►Band safe rates of potassium according to soil tests prior to seeding and broadcast the rest.
- ►When seed drills are not equipped to apply starter fertilizer, fertilizer is broadcast prior to seeding. The tillage action of the drill will incorporate some of the starter.

NOTE: For safe rates of fertilizer, see OMAF Publication 296.

Tubes welded onto the disc furrowers of a ridge till cultivator for liquid nitrogen application.

Nutrient Changes from Tillage Systems

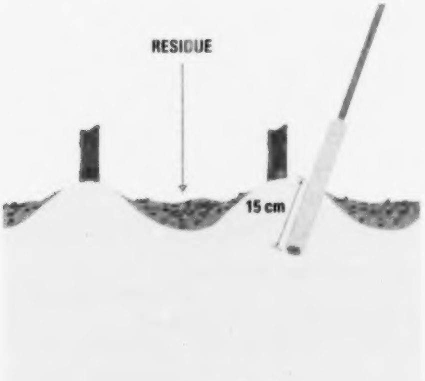
- ► **All nitrogen applied to corn must be placed below the residue.**
- ► **All phosphorus and most potassium are banded.**
- ► **Liquid manure is injected or surface-applied and incorporated.**
- ► **With late summer and fall manure applications, plant a cover crop to soak up the nitrates.**

A couple of different coulters mounted on an anhydrous ammonia applicator. The chain welded on the knife helps to close the slot.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

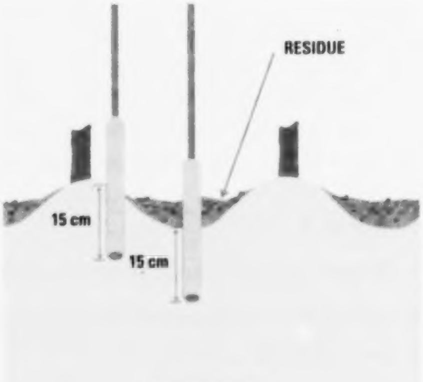
SOIL TESTING

Sample no-till fields the same way that you sample a tilled field except the number of cores should be increased. Ridge till fields may be sampled in two ways:



METHOD 1

Insert the probe to a 15 centimetre (six inch) depth into the side of the ridge, about halfway between the valley and ridge top.



METHOD 2

Take a composite sample of ridges and valleys.

In both systems, take care not to sample in fertilizer bands.

SOIL CHANGES - IMPLICATIONS FOR FERTILIZER MANAGEMENT

Higher levels of organic matter and improved soil structure, combined with increased soil life, improve nutrient uptake by plants. This may lead to reduced fertilizer requirements.

MANURE APPLICATION TO NO-TILL/RIDGE TILL SOILS

In no-till/ridge till systems, tillage is reduced; therefore, manure cannot be properly incorporated. This increases the possibility of loss of nitrogen to the air and contamination of run-off. There is not enough research on manure application in no-till/ridge till to determine the best method and timing of application. The following are the currently recommended methods:

Sidedress Applications of Manure in Corn

Injection

- **Limited by tanker wheel spacing and tire width. Some manufacturers offer tankers with three-metre (120-inch) wheel spacing.**

Surface Application and Incorporation

- **Manure could be surface-applied by a tanker equipped with boom mounted tubes to drop the manure between the corn rows.**
- **Inter-row cultivation with a heavy duty no-till cultivator could incorporate manure.**
- **In ridge till, the manure could be incorporated during the first cultivation.**

Comments

- **A large amount of manure may be needed to meet crop nutrient requirements, depending on soil test results and manure analysis.**
- **Application must take place before the crop gets too tall. Any delays affect the amount of manure injected. Injecting 10% of your manure tank volume at this time may be a reasonable goal.**

Coulters are mounted in front of injectors to cut residue.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Injection - is the preferred method of application using a drag hose or a tanker with injection knives. Straight-edged bubble or ripple coulters are added in front of the injection knife to cut residue. In ridge till, the wheel spacing and tire width of equipment must be adjusted so the ridge is not tramped. The ridge till system of controlled traffic reduces the risk of compaction. In no-till, sweeps could be spaced 76 centimetres (30 inches) apart and the crop could be planted into undisturbed ground in between.

Surface application and incorporation - tillage is not the best option but may be necessary in some situations. Manure is surface-applied and incorporated with a light discing or cultivation.

A tanker surface applies liquid manure between corn rows before inter-row cultivation.

[illegible]

Insects or diseases compete with the crop and restrict its ability to grow. It's important to deal with pest problems right away. Herbicide costs may be higher during the transition period. Insects and diseases are not difficult to control if prevention is practiced.

Pest Changes from Tillage Systems

- ▶ There will be a shift from annual weeds to winter annuals and perennials.
- ▶ Perennials will not be spread by tillage implements.
- ▶ Insects and diseases will be different but with proper management will not be any more of a problem.

WEED CONTROL

Weed control is challenging but certainly not impossible. The ideal situation is that there are no weeds present as the crop emerges. This is often achieved by applying a burndown treatment. A burndown treatment is the application of a non-selective herbicide just before, at, or shortly after seeding the crop. Weeds that emerge after the burndown are controlled by the same pre-emergent and post-emergent herbicides used in other tillage systems.

After a few years of good control, annual weed pressure will decrease. Experienced farmers say, "Use a well-planned, broad-spectrum weed control program during the first few years, then you can worry about fine tuning the program and reducing the amount of herbicide used."

A well timed burndown treatment followed by pre-emergent herbicides provides excellent weed control.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

First cultivation of ridge till corn.

NO-TILL VS. RIDGE TILL: DIFFERENCES IN WEED CONTROL

On the Ridge

In ridge till systems, crops are planted on the ridge every year. The ridge till planter clears residue and soil from the ridges so weed seeds are cleared away. Because ridges can often be planted sooner than no-till, the crop may get a head start on weeds.

Banded Herbicide Applications and Mechanical Weed Control

Aside from the spring burndown, all ridge tillage herbicide applications may be banded on the ridge. Two mechanical cultivations control weeds in the valleys. The usual band width is 25 centimetres (10 inches) which reduces herbicides by about two-thirds. This has less impact on the environment and savings can offset the cost of cultivation. Conversely, labour, fuel and machinery costs increase during the growing season. Pre-emergent herbicide application is not affected by residue since the ridge is cleared at planting. Rotary hoes are also being used to reduce herbicide use on the row.

Small weed escapes within the crop row may be controlled during the ridging pass as soil is pushed up against the crop burying them. This effect will be less important in soybeans if shields are used on the cultivator. These escapes can also be controlled by band spraying a herbicide on the row while cultivating the row middles. This can be done as an overall or spot treatment.

No-till farmers also have the option of banding herbicides and inter-row cultivating once they are comfortable with the no-till system.

Emerging weeds are now controlled with a burndown prior to planting.

CHANGES IN WEED CONTROL

Absence of Tillage and Pre-Plant Incorporated Herbicides - this class of herbicides is not normally used with no-till/ridge till. A burndown treatment is used to replace tillage for early weed control.

Changes in Annual Weed Pressure - tillage kills or suppresses annual weeds but it also brings dormant seeds to the surface. When soil is no longer disturbed, as in no-till, surface seeds eventually germinate and the potential seed bank is reduced. Good weed control in the first few years of no-till/ridge till will decrease annual weed pressure.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Changes in Perennial Weed Pressure - perennial weeds grow deeper into the soil profile and generally spread via underground roots and shoots called rhizomes. With tillage, underground plant parts are cut. This either kills the plant or stunts its growth. Tillage also spreads the cut up roots and rhizomes which, in turn, infest a larger area the following season. Eliminating tillage stops or slows the spread of weeds by that means. Proper herbicide application is important. Identify weeds and attack them when they are young. During the three to five-year transition phase farmers may have to contend with new species such as dandelion, wild carrot or goldenrod, fleabane, while continuing to fight annual and perennial weeds from the conventional system.

Perennial weeds such as quackgrass stay in smaller patches and are easier to control.

CULTURAL WEED CONTROL

Cultivar or Variety Selection - selecting hybrids or varieties for early growth and vigour is important because no-till/ridge till soils tend to be cooler. This allows the crop to compete successfully with weeds.

Seeding Operation - timely seeding controls weeds. Seeding too early into a cold soil may result in a poor stand, while seeding too late reduces the growing season. In either situation, the crop suffers from weed competition.

Cover Crops - development work remains to be done to find more species adapted to Ontario conditions.

Cover crops can affect weed control by:

- Competing with late-season weeds and reducing their numbers and the amount of seed produced.
- Increasing residue which impedes germination and early growth of many annual weeds.

Cautions: Some cover crops become problem weeds and may require special management to prevent interference with the succeeding crop.

- When starting out, don't use cover crops until you are more familiar with the system.
- Seek advice about which species are best suited to your area and crop rotation.

An oat cover crop which has been winter killed.

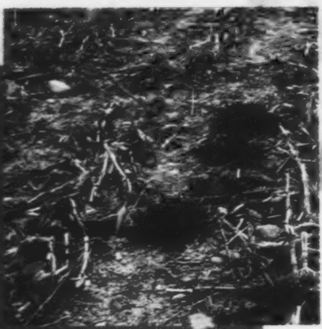
Planning Ahead

- **Identify problem weeds in the fall and control perennial weeds.**
- **Apply fall burndown to control sod, interseeded and cover crops**
- **Apply spring burndown to control escaped perennials, sod, interseeded and cover crops and to control emerging weeds.**
- **Apply spring pre-emergent weed control.**
- **Apply spring post-emergent weed control (chemical and mechanical).**

NOTE: All these treatments may not be necessary but combinations would be used on a farm.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Quackgrass killed prior to planting.



Well established dandelions are hard to kill.

Alfalfa which has been killed in the fall.

CHEMICAL WEED CONTROL

Late Summer and Fall Applications

Fall treatments are preferred for the following reasons:

- ►Added stress of winter can improve control.
- ►2,4-D, dicamba and glyphosate take time to work if applied in the spring, which may delay seeding.
- ►If perennial broadleaf weeds such as Canada thistle and milkweed are present, spring treatments may not work well.
- ►Spring growth may remove valuable moisture needed for the next crop.
- ►Fall treatment reduces the risk of residual herbicides having an affect on the following crop. For example, dicamba affects soybeans.

Alfalfa and dandelions are usually controlled with a fall treatment. Herbicides such as 2,4-D or dicamba may work better on other legumes and broadleaf weeds. A few legume can be tolerated if there is a good control measure available for the following crop

Persistent Broadleaf Perennials - common examples are Canada thistle, field bindweed, sow thistle, milkweed, dogbane, ground cherry, horsenettle and wild carrot. I the fall, perennials move sugar downwards into roots and rhizomes to build up reserves for winter survival and early spring growth. Apply herbicides which absorb through leaves and move down to roots such as glyphosate, dicamba and 2,4-D. If weeds were cu by harvesting operations, allow them time to regrow before spraying.

Germinating Broadleaf Perennials and Winter Annuals - includes the seedlings of broadleaf perennials and winter annuals such as chickweed, shepherds's purse, and fals flax. The herbicides mentioned above can be used when weeds have emerged and are actively growing.

Dandelions - if dandelions are left untreated, they become very hard to kill. It is best to treat them when they are small.

Perennial Grasses: Quack, Brome, Orchard, Timothy - perennial grasses often grow late into the fall and resume growth early in spring. Treat in either spring or fall.

Sod and Cover Crops - old, established grass pastures, grass legume mixtures, alfalfa and clover crops are best killed in the fall if a different crop is to follow.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Burndown at Seeding

Burndown herbicide treatment replaces tillage. Crops are least able to compete with weeds in the early stages of growth, so a timely burndown is essential for success. Time burndown treatments close to crop seeding time. Perennials, winter annuals or cover crops should be controlled one to two weeks prior to crop emergence. If treatments are to follow planting, wait two or three days for weeds to regrow through residue. Non-selective herbicides, such as glyphosate or paraquat, can not be applied once the crop is up.

Weed Control after Burndown

Weed control after burndown and seeding is similar to conventional tillage. For the most accurate, up-to-date information on herbicide use and rates, consult the label or OMAF Publication 75 – A Guide to Weed Control.

Residue has been cleared away from the row to reduce insect and disease problems.

DISEASE CONTROL

The main disease of concern in no-till/ridge till is Fusarium Head Blight. However, no-till/ridge-till systems do not cause this disease; weather is the main culprit. Extended periods of cool and damp weather encourage the spread of plant diseases, although heavy crop residues may increase problems. The following measures prevent problems:

Rotations - crop rotations break the disease cycle. A crop planted into its own residue is more susceptible to disease. Alternate grass family crops with legume family crops. When two crops of the same family follow each other, plant the most susceptible crop first. For example, corn should follow wheat because wheat is more likely to have problems.

Variety selection and seed treatment - choose disease-resistant varieties and be sure to use seed treatments.

Clear residue - add extra coulters or trash whippers to have a residue-free band the crop can grow in.

INSECT CONTROL

In addition to the disease control measures, consider the following:

- When corn follows corn, chop residue to help reduce the corn borer population.
- No-till soybeans following wheat underseeded to clover can result in spider mite infestations in hot dry years.
- Cutworm moths are attracted to heavy residue and winter annuals in early spring. If egg-laying conditions are favourable (e.g. warm, calm, clear nights following storm fronts from the southwest), be on guard.
- Slugs can also cause problems in heavy residue conditions. Cool, damp weather may increase the problem. Remove residue from rows or kill all vegetation before planting.

Management Changes from Tillage Systems

- **Pre-plant incorporated herbicides are no longer appropriate.**
- **Banding herbicides and inter-row cultivation work with ridge till weed control and may be used in no-till.**
- **A burndown herbicide is often used to control weeds prior to crop emergence.**
- **All cover crops, sod crops and inter-seeded crops must be dead before planting.**
- **Avoid planting wheat into corn residue because of fusarium concerns.**
- **Clear residue from the row to reduce slug problems.**

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

EQUIPMENT

BUYING NEW VS. MODIFYING OLD PLANTING EQUIPMENT

There are three ways to describe equipment available for no-till and ridge till systems: Equipment that is specially designed for no-till/ridge till; conventional equipment that is adaptable; or after-market products that convert conventional equipment.

Modifying old equipment may be cheaper but it usually requires a great deal of work. Welding on a frame extension may be necessary. Talk to someone already involved in no-till or ridge till for advice.

Equipment Changes from Tillage Systems

- **Coulters and/or ridge cleaning devices added to the planter.**
- **Use no-till drills or add coulters to the front of conventional drills.**
- **Planters and drills must have adequate residue flow.**

Ridge cleaners attached to the front of a conventional planter.

NO-TILL EQUIPMENT

Evaluating a Drill or Planter

Residue cutting - all equipment should have sharp coulters and/or offset disc openers to cut through residue.

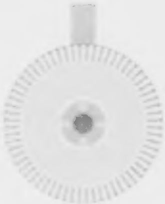
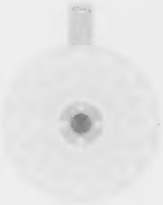
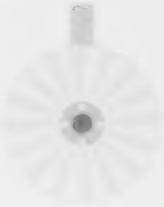
Coulter selection - each coulter differs in use and function. All are designed to penetrate and till soil but vary in the depth of tillage and the horsepower required to pull. The table on the following page provides more detailed information.

Drill with coulter caddy set-up for no-till.

Coulters and trash whippers added to a planter for no-till.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

SELECTING A COULTER

COULTER		COMMENTS
PLOW/RIPPLE		• Relatively low pressure required to penetrate soil. • Cuts residue. • Tills narrow zone of soil.
BUBBLE		• Straight edge cuts effectively. • Shoulders may make penetration of hard soil difficult. • Bubbles at side of coulter provide more tillage than plow type. • Side-wall compaction may result from use in wet conditions.
WAVY/FLUTED		• Wavy edge makes soil penetration more difficult. • Tills the widest area by lifting and shattering soil. • In wet conditions, soil may be thrown out of seedbed.

Soil penetration/tillage - coulters or openers should penetrate soil providing a narrow, tilled seedbed of the right depth and width.

Coulter adjustment - soil conditions may vary within a field so adjustment of coulter depth must be easy. Mounting coulters on hydraulic frames may help when soil conditions are variable.

Weight/strength - approximately 182 kg. per 30 cm. (400 pounds per foot) of drill is necessary to ensure coulters function well. Planter frame strength is important to withstand increased stress on equipment.

Residue flow - arrange equipment so residue flows between openers, coulters and press wheels.

Coulters are staggered to improve residue flow.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

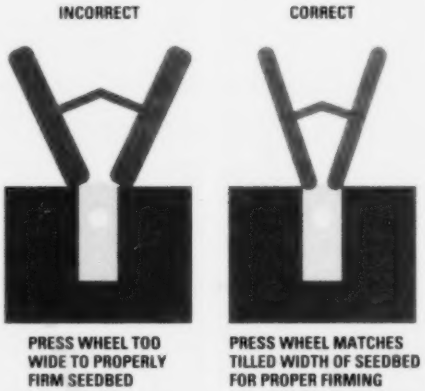
Residue removal and incorporation with the three coulter system.

Residue removal - no-till corn needs a 15 to 20 centimetre (six to eight inch) area with no residue. Add two or more aggressive coulters to either incorporate or toss off residue. Disc furrowers or trash whippers use rotating discs to sweep residue off the row area.

Drive system - reduce wheel slippage by adding fluid, increasing down pressure on wheels, changing to a deeper tread or adding weight to the planter. Reduce coulter slippage by increasing downward pressure or switching to a wider coulter such as the wavy type.

Chain guards - planting into corn residue may dislodge drive chains. Guards prevent this.

Press wheels - no-till coulters tend to leave a loose seedbed. Press wheels firm the seedbed. The correct press wheel depends on the width of the tilled seedbed.


INCORRECT
CORRECT
PRESS WHEEL TOO WIDE TO PROPERLY FIRM SEEDBED
PRESS WHEEL MATCHES TILLED WIDTH OF SEEDBED FOR PROPER FIRMING

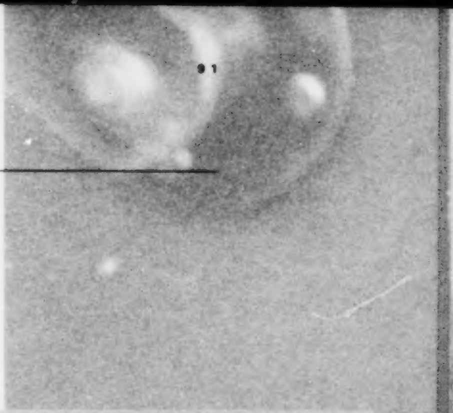
Press wheel selection.

Planting around corners - turning corners is very difficult because of the distance between the front coulters and the rear openers. Swivel coulters can help.

Markers - soil conditions at planting may make it difficult for conventional markers to penetrate soil. Adding weight to the marker arm, using a weight hub on the marker disc blade, or using a notched disc blade will all help.

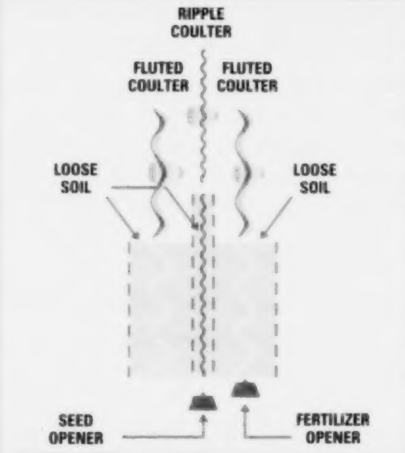
Harrows - seed coverage and crop emergence improve if harrows are added to drills.

No-till drill with harrow added to improve seed coverage.



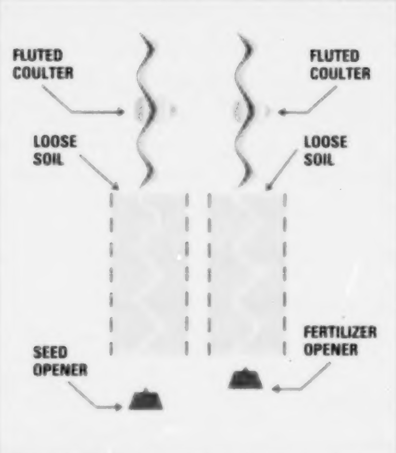
TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

THREE CONCEPTS FOR SELECTING AND PLACING COULTERS ON PLANTERS.


RIPPLE COULTER
FLUTED COULTER
FLUTED COULTER
LOOSE SOIL
LOOSE SOIL
SEED OPENER
FERTILIZER OPENER

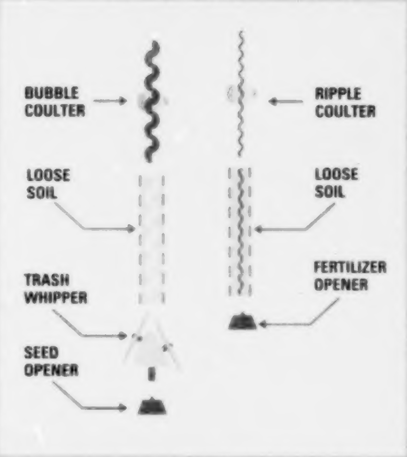
THREE COULTER SYSTEM

Two outside coulters are at least five centimetres (two inches) away from the seed zone. A fertilizer shoe or knife may follow each. The centre coulter (in line with seed opener) ensures the seed slot opener places seed at the proper depth, in tilled soil clear of residue.


FLUTED COULTER
FLUTED COULTER
LOOSE SOIL
LOOSE SOIL
FERTILIZER OPENER
SEED OPENER

TWO COULTER SYSTEM

The two coulters used are set closer together so the tilled zone is narrower. Coulters with left and right arms allow residue to flow between them more easily.


BUBBLE COULTER
RIPPLE COULTER
LOOSE SOIL
LOOSE SOIL
FERTILIZER OPENER
TRASH WHIPPER
SEED OPENER

COULTERS PLUS TRASH WHIPPER

This system normally uses two coulters. If fertilizer units can penetrate untilled soil, only one coulter is needed. This system uses bubble or ripple coulters. The seedbed is very narrow. Residue is removed by trash whippers linked to the seeding unit. There are a variety of configurations depending on the type of residue on the soil.

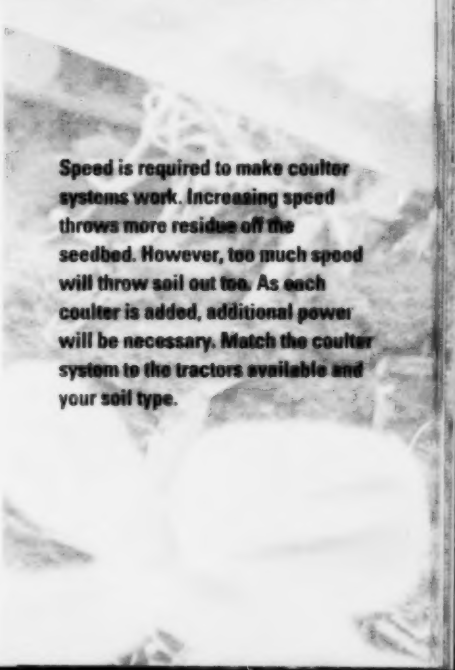
Adjusting Equipment

When using no-till, some additional equipment adjustments are necessary:

Coulter alignment - coulters used to cut residue and till soil should align with seed or fertilizer openers.

Level equipment - start by levelling seeding equipment. This allows proper depth control of both seeding units and coulters.

Soil conditions - plant when the field is dry enough for the coulters to shatter the soil but not throw the soil from the row.



Speed is required to make coulter systems work. Increasing speed throws more residue off the seedbed. However, too much speed will throw soil out too. As each coulter is added, additional power will be necessary. Match the coulter system to the tractors available and your soil type.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Adjust coulter depth - set the coulter depth so that planting equipment prepares a good seedbed. Coulters should run about one centimetre (one-half inch) below the desired seed or fertilizer depth. **In variable conditions, coulters should be mounted on a hydraulically-controlled frame.**

Spring tension - do not tighten too much. Stones in untilled soil won't move so coulters must ride over them.

Starter placement - place starter fertilizer correctly. If it is too close, it will burn the seeds; if it's too far away, seeds won't receive nutrients early enough.

Press wheels - adjust to firm soil around seed not pack it in.

Residue removal - to produce a seedbed that is free of residue, lower trash whippers to move more residue (don't create a trench); or, increase speed to toss residue off the row.

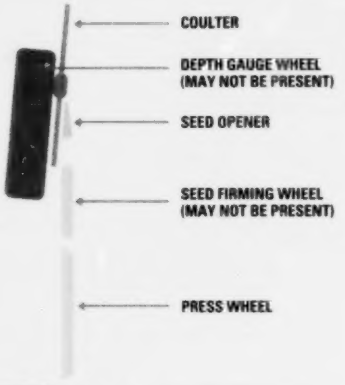
Depth gauge wheels keep the seed from being planted too deep in variable soils.

Seed Drills

No-till seed drills are used to seed most crops except some of the larger-seeded crops like corn and field beans. Their designs vary from a conventional seed drill to models that are specifically designed for no-till. Each drill can do a good job of no-till seeding in certain situations. The trick is to find a drill that will do the job for you.

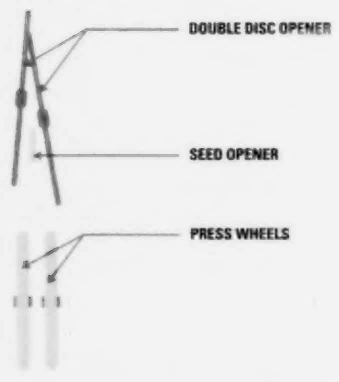
There are a number of features that are common on no-till drills. There are others that have been specially designed to improve performance. There are three drill designs that facilitate seed and fertilizer placement:

Single disc opener - a single straight coulter running at a slight angle tills a narrow seedbed and creates a slot for the seed. The seed is placed in the slot with a shoe positioned directly beside and behind the coulter hub. Some drills have a depth gauge wheel for better seed depth control. Soil is firmed around the seed using a narrow, 2.5 centimetre (one-inch) press wheel.


COULTER
DEPTH GAUGE WHEEL (MAY NOT BE PRESENT)
SEED OPENER
SEED FIRMING WHEEL (MAY NOT BE PRESENT)
PRESS WHEEL

Single disc opener.

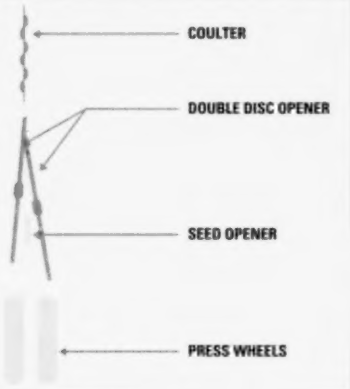
Double disc opener - the seed opener consists of two sharp coulters, one leading the other. By staggering one ahead of the other, a narrower zone is tilled, allowing for easier penetration and better residue cutting. The coulters are normally flat discs with either a smooth or serrated leading edge. Seed is delivered to the seed slot by a tube located behind and between the discs. Depending on the width and extent of tillage, a range of press wheels may be used typically, a single 5 centimetre (two inch) by 33centimetre (13 inch) or a double V 2.5 centimetre (one inch) by 30 centimetre (12 inches).



Double disc opener.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Disc opener + tillage coulter - a tillage coulter leads the seed slot opener. This coulter tills a narrow seedbed for seed and fertilizer placement. As the distance between the opener and tillage coulter increases (as in coulter caddy set-up vs. endwheel no-till drill), the aggressiveness (i.e. the width of the coulter) should be increased. This allows proper tracking of coulter and double disc opener. The seed slot opener can be an offset double disc unit but usually is a conventional unit. The press wheel should be matched to the zone of tillage. The wider the zone, the wider the press wheel.



Disc opener and tillage coulter set-up.

RIDGE TILL EQUIPMENT

Many of the no-till principles apply to ridge till. A properly adjusted ridge till planter will perform the following tasks:

- ▶Clear residue from the top of the ridge.
- ▶Remove a shallow surface layer of dry soil with residue.
- ▶Plant the crop into a clean, moist seedbed on the ridge.
- ▶Place fertilizer and band or broadcast herbicides.

Choosing Planting Equipment

There are two planter setups:

A specialized ridge till planter - includes a planter shoe, a sweep, press wheel, and cover discs.

Ridge cleaning units - can be mounted on an existing toolbar of a conventional planter. In some cases, it may be necessary to bolt on an extra toolbar on which to mount the units. This is simple because it requires very few modifications. Farmers may pull a tool bar with ridge cleaning units independently of the planter. On wet soils, this gives the top of the ridge a few hours to dry once residue is removed. Avoid excessive drying, especially on clay soils.

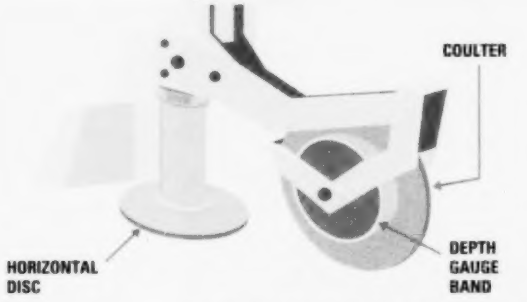
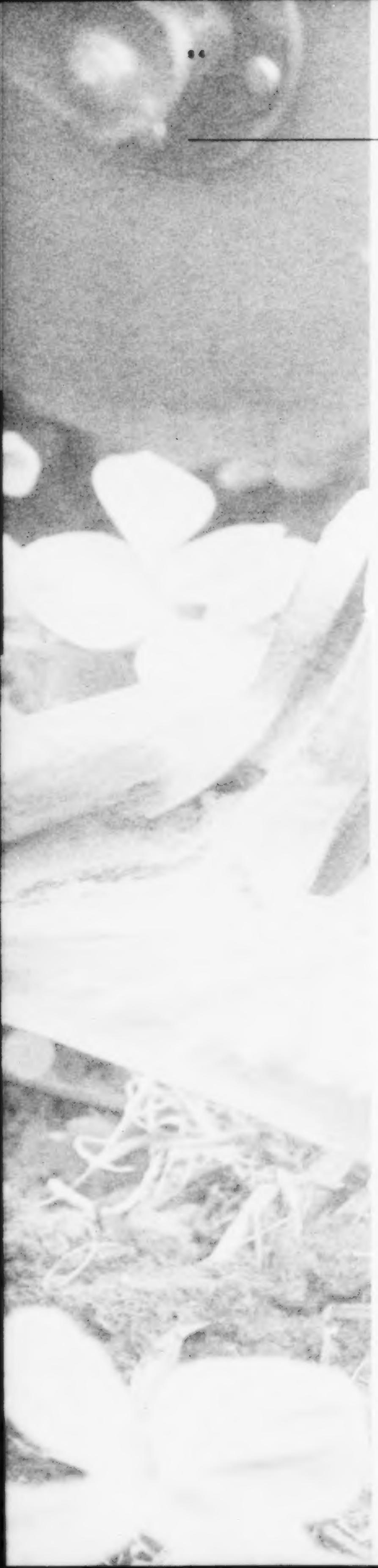


Diagram of a horizontal disc type ridge cleaning unit.

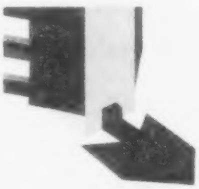
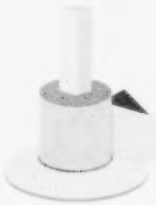
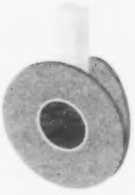
A Closer Look at Planters

Ridge till planters have ridge cleaners to clear residue and a thin layer of soil from the ridge top and a ridge stabilizer to keep the planter on the ridge.



TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Ridge cleaners - most ridge cleaners have coulters with a depth band running in front of them. The depth band maintains a constant working depth. The coulter cuts residue in front of the sweep and cuts a slot approximately four centimetres (1.5 inches) deeper than the sweep to allow the seed unit to penetrate the soil. The coulter also helps keep the planter on the ridge. Remove just enough soil to leave a clear area for planting.

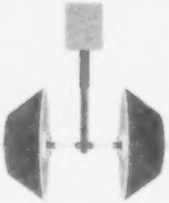
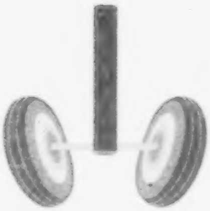
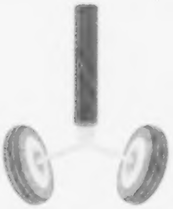
RIDGE CLEANER		COMMENTS
SWEEPS		• Removes 2.5 cm (1") of soil or less. • Clears a level band of soil 25-36 cm (10-14") wide on top of the ridge.
HORIZONTAL DISCS		• A 36 cm (14") disc rotates in either direction deflecting soil and residue off the ridge. • Clears a level band of soil 25-36 cm (10-14") wide. • "Wing deflectors" direct residue into the valleys.
VERTICAL DISCS		• Vertical discs are offset. • Clears a band of soil approximately 20-30 cm (8-12") wide. • Often a sweep or wing is mounted behind the discs to assist in residue clearing and soil levelling. • The new trash whippers with steel fingers are being experimented with for ridge cleaning.

NOTE: The width of soil and residue cleared will depend on the amount of soil removed from the ridge.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Ridge stabilizers - keeping the planter centred on top of the ridge is very important. If it slides off, plant roots may be pruned during cultivation. Converting a pull-type planter to a three-point hitch will help keep the planter from moving off the ridge. Guidance systems will also keep the planter on the ridge.

Proper alignment makes it easier to stay on the ridge.

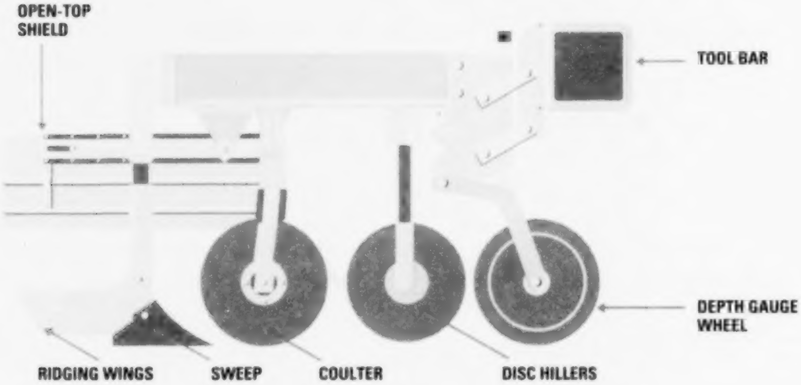
RIDGE STABLILZER	COMMENTS
TAPERED WHEELS 	• Approximately 40 cm (15") in diameter. • Attach to the front of the planter. • The tapered form keeps it in the valley. • One set is attached at each end of the planter.
LARGE "V" WHEELS 	• Approximately 40 cm (15") in diameter. • Attach to the front of the planter. • The wheels ride on the sides of the ridge. • One set is attached at each end of the planter.
SMALL"V" WHEELS 	• Approximately 15 cm (6") in diameter. • Attached to the front of some models of ridge cleaners. • Provide depth control for the cleaning units. • The wheels ride on the sides of the ridge. • There is one set per row.

Proper alignment of coulters, disc openers and press wheels will make it easier to keep the planter on the ridge.

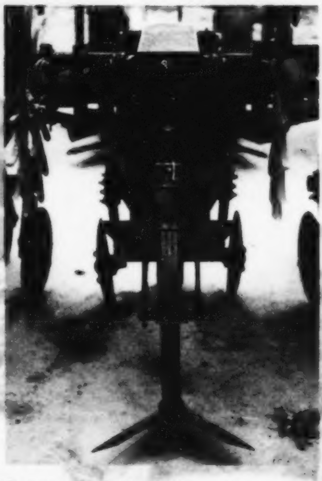
TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Cultivators

These cultivators are designed for high residue conditions to penetrate untilled ground and rebuild ridges. Farmers considering ridge till systems should not try to use conventional cultivators. Ridge till cultivators handle inter-row cultivation and reformation of the ridge. They may also be used to band herbicides, apply nitrogen to corn and broadcast cover crops on the last pass.



Cultivator parts.



Sweeps and disc hillers on a ridge cultivator.

The key parts of the cultivator are:

The tool bar is heavy duty and usually filled with concrete or other material to provide weight for penetration.

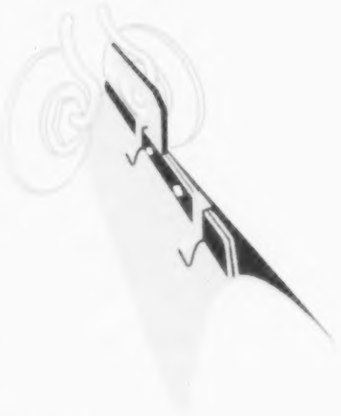
Coulters are mounted ahead of the sweeps and travel in the valleys, cutting through residue. The coulter is straight-edged and at least 46 centimetres (18 inches) in diameter. Cutting depth may be controlled by a depth band or depth gauge wheel.

Sweeps loosen the soil in the valleys and cut off emerging weeds. A 36 or 53 centimetre (14 or 21 inch) sweep is used for 76 centimetre (30 inch) crop row spacings. The wider sweep is used during the first cultivation and a narrow one for the second cultivation/ridging operation. The narrow sweep is used to prevent root pruning. Ridging wings are mounted at the back of the sweep during the second cultivation to deflect soil back onto the ridge. Spring-loaded shanks are available to allow sweeps to ride over rocks.

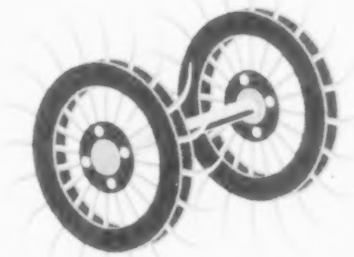
Disc hillers move soil away from the row during the first pass. They should be as close to the row as possible without causing root pruning. They should slightly overlap the herbicide band.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Shields prevent soil from smothering small plants during the first cultivation. Rolling shields remove weeds close to the row but prevent clumps of soil from touching the crop. Open-top shields can be used for any crop height. Hooded shields are also available.



Hooded shield.



Rolling shields.

Other options include:

Fertilizer attachments to sidedress nitrogen include knives to inject anhydrous ammonia gas or tubes to dribble urea ammonium nitrate.

Banding nozzles may be mounted on the cultivator to direct post-emergent herbicides at weed escapes. This can be applied during the first or second pass.

Lift assist wheels attached to three-point hitch cultivators allow the use of smaller tractors.

Guidance systems are used to keep the cultivator on the row. Steel wands which lightly rub against the crop sense where the cultivator is and make adjustments to a hydraulic steering system.

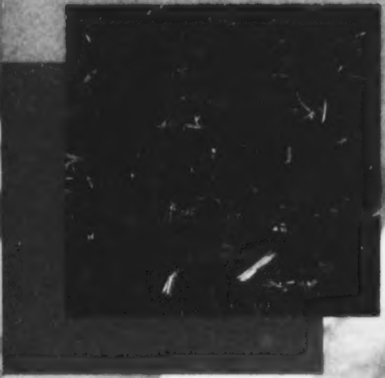
Nurse tank hitch can be added to the cultivator to pull liquid or gaseous fertilizer.

Banding nozzles on a cultivator for spot spraying in the row.

Lift assist wheels on the back of a cultivator.

The sensing wands of a guidance system on a cultivator.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS



A field of soybeans after the first cultivation.

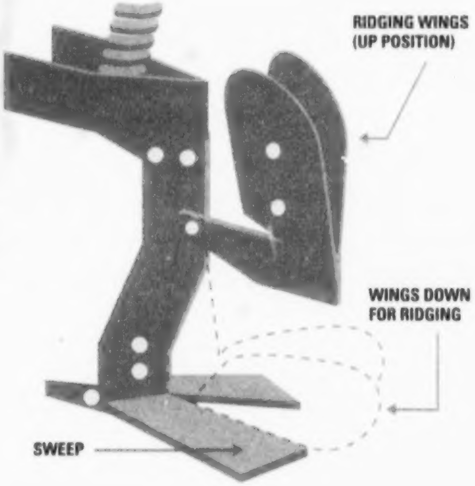
Operating the Cultivator

Inter-row cultivation is performed soon after the crop has emerged when weeds are at the seedling stage. The first cultivation also provides loose soil for ridging. Set the sweep at a depth of five centimetres (two inches). This loosens soil while cutting off weeds. Cultivate again if emerging weeds are a problem. Cultivators are usually operated at speeds of eight to eleven km/hr (five to seven mph).

Ridging is performed shortly after cultivation and before the crop is too tall. A set of wings are moved down into position behind the sweep to force soil onto the crop row. Corn is ridged at 46 to 92 centimetres (18 to 36 inches) tall and soybeans approximately 46 centimetres (18 inches). The ridge should be rounded with a flat top. Corn ridges should be 15 centimetres (six inches) high and soybeans 10 centimetres (four inches) high. Pointed ridges are harder to keep the planter on(see diagram next page).

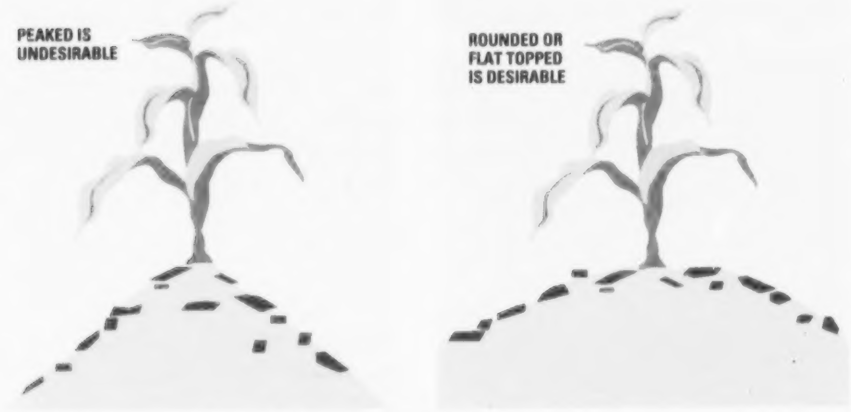
Cultivation should be done when the soil is dry to moist to improve soil fracturing and minimize compaction and smearing. Weed kill is also better. On heavy clay soil, large chunks may form. Adding a deep banding tip or welding metal rods to the sweep will ease the problem. Cultivators with a straight point and wings don't seem to create these chunks.

A deep banding tip on the sweep improves penetration.



During first cultivation the wings are lifted up. Wings are moved down to reform ridges during second cultivation.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS



Ridges should be rounded not peaked to accommodate planting equipment.

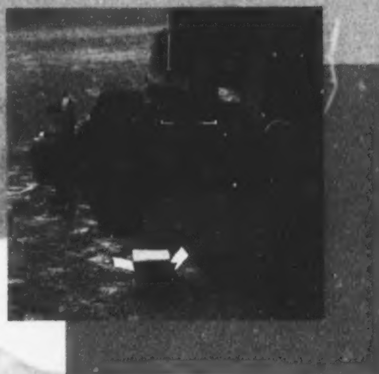
Penetration can be a problem in dry, hard clay. Sweeps should be angled downwards when the cultivator is lowered. A hydraulic cylinder in the top link of the three-point hitch is useful to control the angle of the sweeps and working depth. Deep banding tips will also improve penetration and reduce wear on the sweeps.

Combine Harvester Modifications

Combine wheel spacing can be modified to accommodate row spacing especially in a ridge till system. Spacers are available. Farmers building their own should have them properly engineered.

Choosing to adopt a new tillage system can be confusing. Be aware of what you are getting involved in. Talk to farmers who have been practising no-till or ridge till for more than five years.

It is possible to combine the best of each system to suit a particular farm situation. For example, inter-row cultivate no-till corn. Farmers splitting nitrogen applications find this useful as they are making an extra pass anyway. Dairy and beef farmers gain from hybrid systems.



An extension is added to the axle of a combine to move the wheel off the ridge.

Advantages of Each System

No-till

- **Easy to experiment with.**
- **Less equipment to purchase.**
- **Easy to include forages in rotation.**
- **Less labour. Does not require row crop cultivation.**

Ridge Till

- **More suitable for poorly-drained soils than no-till.**
- **May advance planting date because of earlier spring warm up of soil.**
- **No traffic or soil compaction on ridge.**
- **Manure can be covered with the cultivator and traffic patterns controlled.**
- **Banding herbicides reduces costs.**

THINGS TO CONSIDER

NO-TILL	FIELD SELECTION	Coarse textured soils are easier to manage. Good soil drainage either natural or tile will offset some of the potential soil warming and drying problems associated with increases in residue cover. Try to alternate crop families each year. The easiest place to start no-till is with the winter wheat crop into soybean stubble.
	HARVEST	Harvest time of the previous crop is the time to start thinking no-till. Spread residue the full width of the header. Limit compaction and rutting.
	WEED CONTROL	Assess weed problems immediately after harvest. Post harvest control may be required. The timing of a burndown, whether in the fall or closer to planting time, depends on the weeds to control. Typically, a weed control program involves burndown, pre-emerge, or post-emerge treatments. A rescue treatment may be necessary if the target, timing or method chosen were inaccurate.
	PLANTING	Set up a suitable planter/drill that accurately places seed and fertilizer in untilled soil. Plant when residue is dry or brittle. All residue should be dead.
RIDGE TILL SYSTEM	FIELD PLANNING	Sands are easier to manage than silts or clays. Ridges should run across the direction of the tiles. Think about the crop rotation.
	BUILDING THE FIRST RIDGE	The first ridge is formed in the corn crop. Till the field conventionally. Plant with a conventional planter. Purchase a ridge cultivator. Set up and adjust to form a 15 cm (six-inch) high, flat-top ridge. Conduct when corn is 46 cm (18 inches) high.
	HARVEST	All wheel spacing must be adjusted to avoid running on the ridge. Consider controlled traffic ie. all wheel tracks down the same row. Ensure even residue distribution at harvest.
	PLANT RIDGES	The first crop planted on the ridge is soybeans. The series of operations are as follows: burndown, plant and band herbicide, cultivate, cultivate and ridge (see note below).
	HARVEST	Ensure even residue distribution. Scout field for weed problems. Chop corn stalks, if required.

NOTE: - Corn - a 15cm (six-inch) high ridge. - Soybeans - a 8-10 cm (three or four inch) high ridge provided the bottom pods are harvestable. If wheat is to follow soybeans, no re-forming of the ridge is done during cultivation.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

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TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

NO-TILL CASE STUDY

This southwestern Ontario cash crop farm was suffering from severe water and wind erosion in the early 80s. Since adopting no-till in 1982, soil erosion has been greatly reduced, soil structure has improved and profits have increased.

FARM DESCRIPTION & BACKGROUND INFORMATION

Soil types - heavy clay, sand, gravel, silt loam.
Topography - rolling, no surface ponding.
CHU - 3300.

EVALUATION OF SITUATION IN 1981

- Too much rill and gully erosion, a bulldozer was necessary to repair fields in the spring.
- Organic matter depletion contributed to soil sealing and crusting.
- Farmer was very concerned about future of farm. A solution was needed to stop soil from moving off the farm.
- A conventional tillage system was used and there were no conservation measures in place.
- Crop rotation - corn and soybeans.

GOALS

- Reduce soil erosion to acceptable levels.
- Improve soil organic matter levels and eliminate soil crusting.

ALTERNATIVES CONSIDERED

- Erosion control structures.
- Rotations with forage crops and cereals.
- Minimum tillage, no-tillage.
- Combinations of the above.

SELECTION

- No-till was chosen because it provided the most soil protection while maintaining farm income.
- Wheat was added to the rotation for soil structure improvement.

INITIAL CONCERNS

- Weed control, residue management and getting the planter to cover seed properly were all concerns.

A field on the case study farm of no-till corn in wheat stubble.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

IMPLEMENTATION

Information Sources

▶ Ohio Conservation Districts, farmer to farmer networking, government researchers.

The spray boom mounted on the front of the tractor for spot spraying.

Machinery Changes

PLANTER:	YEAR 1	▶ Added no-till bubble coulters on each unit of conventional planter, installed oscillating depth stops on units (very important on some planters) and added cast iron press wheels. ▶ Water was put in liquid fertilizer tanks for weight when planting soybeans. ▶ One planter was used to plant both corn and soybeans.
	YEAR 3	▶ Replaced fertilizer openers with a coulter and knife.
	YEAR 4	▶ Due to the larger acreage being farmed and the variability of soil types the original planter became the soybean planter and a second planter was purchased for corn. ▶ Added an extra tool bar with two wavy coulters (1" for soybeans, 2" for corn) per row to better prepare seed area and one of the wavy coulters with a knife replaced fertilizer coulters and knife for better placement. Weight was added to markers and joints were reinforced. Also a spray boom was added to the back of the planter for pre-emergence herbicide application.
	YEAR 6	▶ The tillage of the wavy coulters meant that the cast iron press wheels were no longer needed. Put conventional ones back on. Liquid fertilizer tanks were added to apply a portion of the nitrogen requirement.
	YEAR 7	▶ Added nozzles to band spray herbicides.
SPRAYER:		▶ Pull type with foam markers. ▶ Hydraulic floating boom - can raise or lower on the move. ▶ Added a boom to the front of the planting tractor to spot spray quackgrass.
ROW CROP CULTIVATOR:		▶ Was purchased to allow banding of herbicides. ▶ Used for corn only - has spray nozzles to band herbicides in row during cultivation if needed. ▶ Used to apply liquid nitrogen for corn. ▶ A note of caution: Row crop cultivation disturbs the residue cover between the rows. On a wet fall it may be necessary to delay harvest for a few days to avoid rutting. Combine wheel spacing may have to be changed to run between the rows.
WICK WEEDER:		▶ Purchased to control milkweed and dogbane.

Nutrient Management

Soybeans - no fertilizer.

Wheat - broadcast ammonium nitrate in spring, super-phosphate in fall.

Corn - broadcast potassium as needed.
- 60 lbs/acre of actual N at planting - (mixture of 28% and 10-34-0.)
- remaining N applied during cultivation - (28% liquid U.A.N.)

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Crop Rotation

- ▸Corn - Soybeans - Soybeans - Wheat.
- ▸Wheat fields with clover were staying too wet the following spring. The clover is now sprayed in the spring instead of the fall. Growing clover helps field drying in the spring.
- ▸Farmer chose soybean varieties which gave a taller plant and were resistant to phytopthora root rot.

Weed Control

- ▸Velvetleaf has been greatly reduced because tillage no longer aids germination. Seeds remaining on surface do not germinate as readily.
- ▸Canada thistle is now under control as the patches are no longer spread with tillage.
- ▸Weeds generally are now easier to control.

COMMENTS

All of the initial concerns were overcome.

When first starting out, there was no one else in the area going through the same process.

A farmer group was important for exchanging information and to help keep morale up.

The no-till system has reduced equipment, labour and fuel costs per acre.

EVALUATION

- ▸Residue protects soil from rain and winds, soil remains in place.
- ▸Organic matter levels have increased.
- ▸Residue cover has reduced soil crusting.

REMAINING PROBLEMS AND PLAN OF ACTION

- ▸Erosion still occurs in runways where concentrated flows of water occur. Runways will be grassed to form permanent grass waterways.

RIDGE TILL CASE STUDY

This cash crop farm is located in southwestern Ontario. Once the ridge tillage system was successfully implemented the owner decided to try strip cropping.

FARM DESCRIPTION & BACKGROUND INFORMATION

Soil types - sandy loam to clay loam.
Topography - level to gently sloping.
CHU - 3250.

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

A group of farmers visit the case study farm to learn more about ridge till.

EVALUATION OF SITUATION IN 1981

- Too much wind, sheet and rill erosion.
- Poor soil structure, low soil organic matter levels and soil compaction.
- Low profits.
- Conventional tillage used with no conservation measures.

GOALS

- Improve soil condition.
- Reduce costs and increase profits.

ALTERNATIVES CONSIDERED

- Mulch tillage and then later ridge tillage.

SELECTION

- Although a chisel plow was successful, it was not good enough. Still too much time and money involved in tillage operations.
- Ridge tillage was tried and since then have never looked back.
- Strip cropping was a natural progression of ridge tillage because of the established traffic patterns.

INITIAL CONCERNS

- Compaction in traffic areas between ridges.
- Ridge not staying on sandy soil.

IMPLEMENTATION

Information Sources

- "More Profit With Less Tillage" - Ernie Behn, farmer to farmer networking.

Machinery

PLANTER:	▸ Double frame semi-mounted with lift assist wheels. ▸ Kinze planter units with Hiniker horizontal disc ridge cleaners. ▸ Hiniker V-wheels used to stabilize planter on ridge.
SPRAYER:	▸ Pull type, 500 gallon with 15, 30 & 45 foot booms.
CULTIVATOR:	▸ Hiniker Econo-Till - 6 x 30". ▸ Hiniker 5000 - 6 x 30". ▸ 2 Sukup "autoguide" guidance systems.
COMBINE HARVESTER:	▸ Case IH 1660 with 24.5 x 32 tires, 6 x 30" corn head, 15 foot flex head, 6 x 30" John Deere row crop head. (used for soybeans).

TILLAGE OPTIONS – NO-TILL AND RIDGE TILL SYSTEMS

Nutrient Management

Soybeans - no fertilizer.
Wheat - 80 lbs amonium nitrate sidedress.
Corn - 3 gallons of 6-24-6 on seed
  - 100 lbs 12.5-0-37.5 banded in ridge
  - 150 lbs actual N as anhydrous ammonia sidedress.
Potash deficiency - banded potash in ridge.

Crop Rotation

►Corn - Soybeans - Winter Wheat.
Strip Cropping - Corn-soybeans-wheat are strip cropped in 15 ft widths.
  - Higher populations are planted on the outside corn rows.
  - Soybeans must resist lodging in strip cropping.
  - Wheat is no-tilled into soybean ridges.
►Experimenting with hairy vetch & red clover after wheat.
►Cold tolerant hybrids are important.

Corn - soybean - winter wheat strips.

Weed Control

►Dandelions initially a problem.
►Wirestem muhly mainly a problem in corn.
►Trees can be a problem - willow and walnut.

COMMENTS

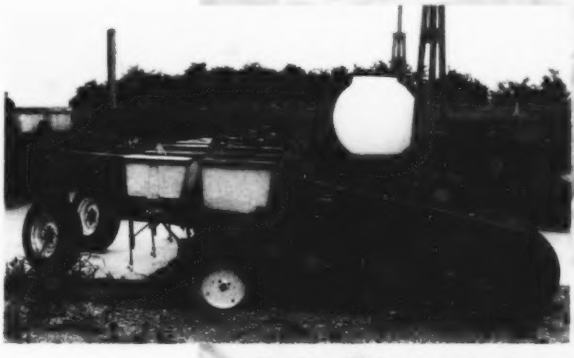
►System allows for strip cropping due to permanent nature of ridges.
►Traffic is controlled off row area.
►Chemical can be banded to reduce cost and potential environmental impact.
►Yields do not drop during first years.
►Works well on all soil types on the farm.

EVALUATION

►Residue incorporated in top 1" - 2" of soil has improved structure.
►Small tractors have helped reduce compaction.
►Surface residue prevents wind erosion.
►Initial concerns were not a problem.

REMAINING PROBLEMS AND PLAN OF ACTION

►Some soils need more organic matter.
►Possible use of compost or cover crops to help correct this problem.



The ridge till planter used on the case study farm.

TROUBLE SHOOTING

PROBLEM	CAUSE	SOLUTION
Planter plugging with residue	• Poor residue flow	• There should be adequate space between seed units, press wheels lift wheels etc. to allow for good residue flow. Residue flow can be improved on drills by staggering the seed units. **Nt**-drive at an angle to old crop rows.
	• Too much residue	• **Nt**-drive at an angle to old crop rows. **Nt**-plant between old crop rows. Remove straw from cereal fields. Spread residue evenly at harvest. **Rt**-shred corn stalks. Rotate between high and low residue crops i.e. corn and soybeans.
	• Residue not cut	• Use a 43 cm (17") coulter in front of the planting unit. Make sure coulter blades are sharp. Delay planting until residue is dry. Adjust coulter depth.
Planter will not stay on top of ridges	• Improper planter set-up	• Make sure all the coulters and cleaners are aligned properly and are set at a uniform depth. Make sure planter is level from front to back. Add a guidance system. Add ridge stabilizers.
Seed and fertilizer placement too shallow	• Poor coulter penetration	• Add weight to planter frame. Adjust tillage coulter depth. Use narrower coulter. Avoid planting when soil is too dry and hard. Ensure coulters are sharp.
	• Poor tracking of seed/fertilizer unit	• **Nt**-line up tillage coulter with openers. **Nt**-on coulter caddies a wider more aggressive coulter may be necessary.
	• Planter unit bounce	• Install oscillating depth stops. Use a row cleaning device. Increase seed unit down pressure.
	• Poor seed unit penetration	• Adjust seeding depth of unit. Adjust spring pressure on the unit and on the press wheel(s). Replace seed unit disc openers. Align tillage coulters with openers.

Nt - Specific to no-till.   Rt - Specific to ridge till

TROUBLE SHOOTING CONTINUED

PROBLEM	CAUSE	SOLUTION
Seed and fertilizer placement too deep	• Tillage coulters set too deep	• Raise coulters. Reduce pressure on springs.
	• Seed units too deep	• Adjust depth setting on the units. Add depth stops to the lift wheels.
Poor seed trench closure	• Inadequate firming of soil	• Increase down pressure on press wheel. Change to a narrower press wheel.
	• Soil too wet	• Wait for soil to dry. Kill vegetation sooner and thus speed soil drying. Install tile drainage.
Erratic seed drop/skips	• Slipping drive wheel/coulter	• Add weight to planter or drill. Add fluid to drive wheel. Change to a more aggressive drive wheel/coulter.
Poor seed-to-soil contact	• Hairpinning	• Remove more residue from the row. Install tillage coulters in front of openers. Sharpen coulters. Replace worn seed unit disc openers.
Poor germination and emergence	• Cool soil temperature	• Install tile drainage in poorly drained areas. Delay planting until soil warms up. Clear residue out of the plant row. Till the soil in plant row. Kill growing vegetation sooner i.e. in the fall before vegetation becomes too dense.
	• Seed and seedling disease	• Use a seed treatment. Rotate crops. Select varieties for disease resistance. Use high quality seed.
	• Inadequate soil moisture	• Plant into dead residue, burn off weeds or cover crops well before planting. Control red clover and alfalfa in the fall. Plant earlier.

Nt - Specific to no-till.   Rt - Specific to ridge till

TROUBLE SHOOTING CONTINUED

PROBLEM	CAUSE	SOLUTION
Poor root growth	• Soil compaction	• Avoid traffic on field when wet. Utilize rotations or cover crops which improve soil structure.
	• Wet soils	• Improve surface and subsurface drainage.
	• Fertilizer burn	• Make sure product rates are safe. Make sure product is safe. Check that placement is not too close to seed.
Poor early growth and reduced stand	• Seed planted too deep	• Plant just into moisture usually 2.5 to 4 cm (1" to 1.5") deep (especially for early corn).
	•Too much ridge scraped off	• **Rt**-scrape off only enough to reach moisture, avoid exposing less well structured soil.
	• Nutrient deficiency	• Use starter fertilizer to improve early uptake. Soil test to determine fertility problems.
	• Cool wet soil	• Select varieties and hybrids with good seedling vigour and early cold stress tolerance. Improve drainage.
	• Detrimental effects from decomposing residues	• Avoid planting crop into its own residues. Alternate grass and legume type crops.
Nutrient deficiency	• Low soil nutrient levels	• Soil test and apply recommended nutrients.
	• Low nutrient availability	• Band phosphorus and potash in row area.
	• Poor nitrogen placement	• Inject all nitrogen for corn below residue.
	• Nitrogen losses due to denitrification	• Improve drainage and soil structure. Apply nitrogen close to when it is required.
Poor weed control	• Vegetation not controlled prior to emergence	• Use a burndown herbicide prior to crop emergence. Identify weeds prior to planting. Match the burndown treatment to weeds present.
	• Failure to recognize change in weed spectrum	• Scout for weeds on a regular basis. Select the appropriate weed control method for your weeds.
	• Improper timing	• Control the weeds at the proper growth stage (remember in no-till weeds get off to an earlier start).
	• Cultivator throwing weeds back in row	• Replace sweep with 5 cm (2") straight chisel tooth on 1st cultivation. Drive slower.

Nt - Specific to no-till   Rt - Specific to ridge till

TROUBLE SHOOTING CONTINUED

PROBLEM	CAUSE	SOLUTION
Disease	• Susceptible varieties	• Select disease resistant varieties.
	• Poor crop rotation	• Follow a better cropping sequence. If cover crops are used, ensure that they break the disease cycle. Use seed treatments. Avoid planting wheat into corn residue.
Cultivator will not go into the ground	• Not enough weight on cultivator	• Add weight, adjust down pressure spring.
	• Sweep angle not correct	• Install hydraulically adjustable top link on 3-point hitch.
	• Sweeps worn	• Replace, or install deep banding tips.
Cultivator makes too many slabs, knocks down corn	• Cultivating too deep	• Adjust depth gauge wheels.
	• Soil structure problems	• Rotate to cereals to improve surface structure. On first cultivation replace sweep with 5 cm (2") straight chisel tooth. Deep banding tips will help.
Cultivator plugging with residue	• Residue too damp	• Allow to dry out.
	• Cultivator not set deep enough	• Adjust depth gauge wheels.
	• Uneven residue distribution	• Install straw spreader on combine.
Cultivator will not track straight	• Gauge wheels not at same depth	• Set them all at the same depth.
Guidance system not tracking properly	• Wands not sensing the row	• Use setup where two wands channel one crop row rather than two rows.

Nt - Specific to no-till   Rt - Specific to ridge till

NON-TILLAGE OPTIONS

An investigation into how much erosion has taken place on fields helps plan the best use for land.

INTRODUCTION

This section provides tools which can help farmers control soil erosion and protect water resources. When soil moves off individual fields or the farm, it takes valuable nutrients, pesticides and organic matter. Farmers cannot afford the economic loss, nor the adverse environmental impacts of allowing soil to wash or blow away.

Some conservation practices will cost money. But, money spent in a rational manner is a sound investment. Increased yields and reduced production costs will make up for short-term losses in as little as two or three years.

Conservation practices (such as those outlined in this section) allow safe removal of surplus water that falls on the land or offer protection against damaging winds. However, a good conservation plan also must include wise use of fertilizers (whether commercial or livestock manure), careful handling of pesticides, enhancement of fish and wildlife habitat and maintenance of wetlands. Conservation will protect the land and improve its production base. It also increases land value.

It is impossible to recommend a single preferred list of management options to Ontario farmers. Practices must be tailored to individual fields on each farm. Each conservation plan must meet the objectives of the individual producer.

Legislation

As with any industry, agriculture is regulated by Provincial and Federal law. Several existing statutes could apply to conservation planning:

Provincial Statutes

- ►Lakes and Rivers Improvement Act
- ►Ontario Water Resources Act
- ►Environmental Protection Act
- ►Pesticides Act
- ►Conservation Authorities Act
- ►Public Lands Act
- ►Drainage Act

NON-TILLAGE OPTIONS

Federal Statutes (Take Precedence Over Provincial Statutes)

- The Canadian Fisheries Act
- Navigable Waterways Protection Act

There may also be bylaws in your local municipality which may affect your plans. It is your responsibility to ask questions first and meet all requirements and obtain necessary permits.

Land Use Capability

The first and most important step in conservation farming is using the land within its capability. Select a reasonable land use program in order to succeed in other parts of the conservation system.

Selecting a good land use for each field is partly a matter of deciding whether the field is suited for crops, pasture, woods, wildlife or recreation.

In agricultural terms, land can be classified into two broad categories, that which is suited for crop production and that which is best suited for permanent grass or trees. Although land is suited for cropland, it may still require special treatment such as contouring, simple water management, crop rotations or conservation structures. Land designated as non-cropland may be suited for pasture, woodlot or retired from farm use altogether.

Consider the alternatives when preparing a conservation plan. If necessary, consult experienced planners for help.

NON-TILLAGE OPTIONS – CONSERVATION PRACTICES FOR CROPLAND

CONTOURING AND GRASS FIELD BORDERS

On short, gentle slopes, contour farming provides good protection against erosion. Tilling and planting across the natural slope create a series of dams which hold back water until it can soak into the ground.

For all but severe storms, contour farming on fields as steep as a 9% slope will cut erosion rates in half.

Contouring has no 'out-of-pocket' expenses and it can increase yields by 5 to 10%. Fuel and machine costs decrease, when compared to land farmed up-and-down the slope.

Getting started in contouring is not difficult. Expect, that because of slope irregularities, it may not always be possible to stay on the level. When laying out your system, smooth curves at ridge tops and drainage ways and square the rows with field edges to eliminate 'point-rows'.

These adjustments should maintain a 0.5 to 1% grade along rows. A grass waterway or tile outlet terrace must then be considered to carry surface water down the slope.

Tools which make laying out contours easy include specially-designed gauges (shown), hand and stationary levels.

The full benefits of contouring are obtained if all field operations are on the contour.

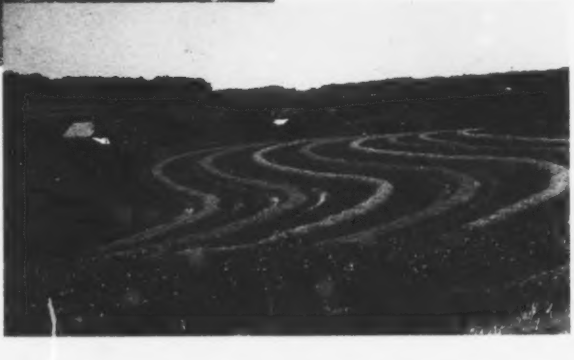
This producer has started mulch tillage with contouring and terracing to solve erosion problems.

The Contour Gauge is attached to the side window of a truck or tractor. It makes contour layout easier. Drive across the field keeping the bubble centred. Your local extension person may know where one is available.

▲ An important part of any contour system includes grass field borders or headlands.

Farming on the contour, compared to up-and-down the hill can cut erosion rates in half. Moving to a no-till system, as shown here, may reduce erosion by up to 90%.

Contour strip cropping with corn and small grain reduces erosion by up to 50% when compared with up-and-down the hill farming. It also doubles the allowable slope length limit shown in the table. ▼



NON-TILLAGE OPTIONS – CONSERVATION PRACTICES FOR CROPLAND

The following limits should be considered when planning for contour farming.

SLOPE LENGTH LIMITS FOR CONTOURING

[illegible]	MAXIMUM SLOPE LENGTH (METRES)	(FEET)
[illegible]	120	(400)
[illegible]	90	(300)
[illegible]	60	(200)

On longer slopes, contouring can be effective by using it in combination with conservation tillage, terraces, strip cropping or contour buffer strips.

Erosion can be severe where headlands are farmed up-and-down the hill. Grass field borders will limit erosion and provide an area to turn farm equipment.

Yield increases through contouring should easily offset production losses from land seeded into grass field borders.

STRIP CROP FARMING

Strip crop farming refers to planting alternating strips of a row crop with a cereal crop or forage. This practice combines the soil and moisture savings of contouring with the soil building advantages of a crop rotation.

There are four kinds of strip cropping: contour, field, contour buffer and wind strip cropping. The system you choose depends on the crops that can be grown, the kind of erosion (wind or water), the topography and the soil type.

Contour Strip Cropping

Crops are arranged in bands at right angles to the natural slope of the land. In nature, slopes are seldom perfectly uniform. Therefore, compromise in the contour layout. While it is difficult to imagine, if both strip edges are on the contour, all strips will be irregular in width. Consider alternating irregular-width strips with one or more even-width strips.

Take extra time and care to plan your rotation to ensure good erosion control. Laying out contour strip cropping is complicated, so get technical assistance.

Several tools may be used in laying out contour strip cropping. They include levels or Contour Gauges and measuring tapes.

[illegible]

SLOPE LENGTH LIMITS FOR CONTOURING

LAND SLOPE (%)	MAXIMUM SLOPE LENGTH (METRES)	(FEET)
1 - 2	120	(400)
3 - 5	90	(300)
6 - 8	60	(200)

[illegible]

[illegible]

[illegible]

STRIP CROP FARMING

[illegible]

[illegible]

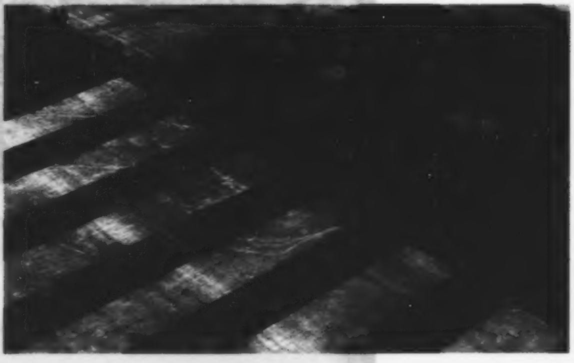
Contour Strip Cropping

[illegible]

[illegible]

Several tools may be used in laying out contour strip cropping. These include levels or Contour [illegible] and measuring tapes.

NON-TILLAGE OPTIONS – CONSERVATION PRACTICES FOR CROPLAND



Grass field borders allow access to each strip and are a necessary part of strip cropping systems.

Field Strip Cropping

This is the most common form of strip cropping. It maintains strips of uniform width across the slope. As with contour strip cropping, this system can reduce erosion by up to 75% when compared to up-and-down hill farming.

In laying out this type of system, refer to the recommended strip widths shown on the following table. Adjust these dimensions to blend with equipment widths, especially planters and sprayers. An even number of passes along each strip will allow field operations to start and finish at the same end of the field.

[illegible]

[illegible]	[illegible]	[illegible]	MAXIMUM SLOPE LENGTH METRES	(FEET)
[illegible]	[illegible]	[illegible]	240	(800)
[illegible]	[illegible]	[illegible]	180	(600)
[illegible]	[illegible]	[illegible]	120	(400)
[illegible]	[illegible]	[illegible]	75	(240)

Across slope or field strip cropping is easy to understand and manage. Terraces or grass waterways protect areas where surface run-off concentrates.

Grass field borders become an integral part of any strip cropping system. They provide access lanes to each strip, protect against erosion and offer habitat to wildlife.

Contour Buffer Strip Cropping

Permanent strips of grass or forage laid out between even-width strips of crops in regular rotation, also limits erosion.

Grass strips as narrow as four metres (13 feet), making up as little as 10% of the entire field, may reduce erosion rates by up to 55% while doubling the slope length limits for contouring.

Buffer strip locations are based on crop rotation and the severity of slope. On irregular slopes, grass strips will be of different widths to make annually-cropped strips even.

NON-TILLAGE OPTIONS – CONSERVATION PRACTICES FOR CROPLAND

[illegible]

[illegible]	[illegible]			MAXIMUM SLOPE LENGTH	
	[illegible]	[illegible]	[illegible]	METRES	(FEET)
[illegible]	[illegible]	[illegible]	[illegible]	240	(800)
[illegible]	[illegible]	[illegible]	[illegible]	180	(600)
[illegible]	[illegible]	[illegible]	[illegible]	120	(400)
[illegible]	[illegible]	[illegible]	[illegible]	75	(240)

Wind Strip Cropping

Wind erosion can be a hazard, especially for soils on level land. For good erosion control, alternate strips should be even in width, parallel and laid out cross-wise to the prevailing winds.

This easy, do-it-yourself table recommends widths based on soil texture. See the booklet BMP for Horticulture Crops for more ideas.

A sensitive tobacco crop is protected from wind by planting alternating strips of small grain.

[illegible]

Grass field borders allow access to each strip and are a necessary part of strip cropping systems.

Field Strip Cropping

[illegible]

[illegible]

MAXIMUM STRIP WIDTHS AND SLOPE LENGTH LIMITS FOR CONTOUR AND FIELD STRIP CROPPING

LAND SLOPE (%)	STRIP WIDTH METRES	(FEET)	MAXIMUM SLOPE LENGTH METRES	(FEET)
1 - 2	40	(130)	240	(800)
3 - 5	30	(100)	180	(600)
6 - 8	30	(100)	120	(400)
9 - 12	25	(80)	75	(240)

[illegible]

Across slope or field strip cropping is easy to understand and manage. Terraces or grass waterways protect areas where surface run-off concentrates.

Contour Buffer Strip Cropping

[illegible]

[illegible]

[illegible]

SOIL LOSS REDUCTIONS (SHADED) AND SLOPE LENGTH LIMITS FOR CONTOUR BUFFER STRIP CROPPING

LAND SLOPE (%)	PERCENT OF FIELD IN GRASS 10%	30%	50 %	MAXIMUM SLOPE LENGTH METRES	(FEET)
1 - 2	45	60	70	240	(800)
3 - 5	55	65	75	180	(600)
6 - 8	55	65	75	120	(400)
9 - 12	45	60	70	75	(240)

Wind Strip Cropping

[illegible]

[illegible]

RECOMMENDED WIDTHS FOR WIND STRIP CROPPING

SOIL TEXTURE	STRIP WIDTH METRES	(FEET)
Fine sand, fine sandy loam, clay	25	(80)
Loam, silty loam	80	(260)
Clay loam, silty clay loam	100	(330)

A sensitive tobacco crop is protected from wind by planting alternating strips of small grain.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR CROPLAND

Good artificial drainage may be the key to successful implementation of other best management practices.

TILE DRAINAGE AND WATER TABLE MANAGEMENT

Good land drainage is necessary for all farm operations. There is no question about the value of tile drainage to farm production on some soils. It will increase the yield of most crops and improve the efficiency of the overall operation by artificially removing excess water from soil.

Subsurface drainage is an important conservation practice. It can reduce surface run-off during some seasons by allowing more water to soak into the soil.

In the past, underground tiles were installed simply to remove excess water from soil. Recently, however, research shows these drains may also serve as a water supply or irrigation system. By regulating water flow in the drains, groundwater levels are maintained near the bottom of the crop root zone. Good soil moisture levels results in increased crop production.

In the United States, this is now an accepted best management practice. Nutrients and chemicals are used more efficiently by the crop rather than being released out of a tile drain.

An aerial view of two parallel, narrow base terraces with tile outlet. Designed to break up the slope length, terraces reduce erosion by up to 75% and allow more intense crop rotation.

TERRACES

Terraces reduce erosion by controlling and managing surface run-off. A terrace is a channel with a supporting downslope ridge constructed across the slope. Terraces break up long slopes into a series of short ones with each one collecting excess water from an area above it. The collected water is then removed from the field safely.

Terraces are the most expensive conservation practice. However, they allow for more intensive row cropping while keeping erosion in check. Studies in the United States show crop yields on terraced land are 10 to 15% higher than those on erodible land that is not terraced. Full recovery of construction costs can occur in as little as three years.

Terraces make more economic sense when combined with other conservation practices such as contouring, strip cropping, or conservation tillage.

Producers may construct their own terraces by renting a tractor-pulled earth scraper.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR CROPLAND

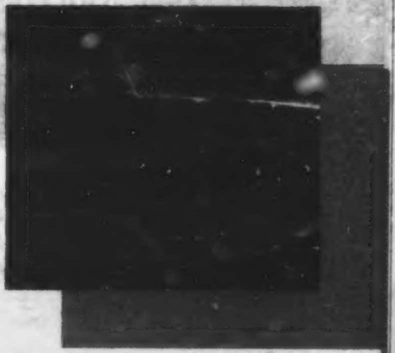
RECOMMENDED TERRACE SPACING WITH AND WITHOUT A CONSERVATION MANAGEMENT SYSTEM

WITHOUT CONSERVATION MANAGEMENT SYSTEM METRES	(FEET)	WITH CONSERVATION MANAGEMENT SYSTEM METRES	(FEET)
90	(300)	120	(400)
75	(250)	110	(350)
55	(180)	90	(300)
45	(150)	75	(250)
35	(120)	60	(200)

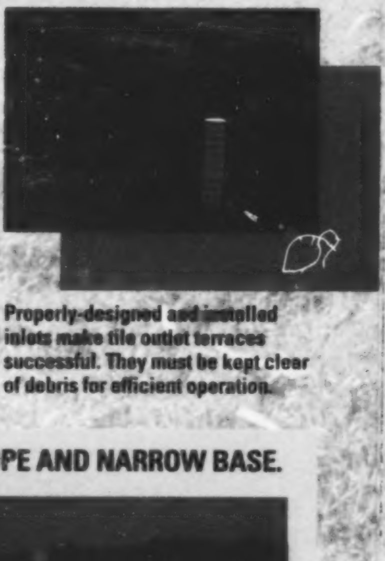
Steepness of slope, soil erodibility, crop type, management and rainfall, all determine terrace spacing. Adjustments are then allowed for matching equipment dimensions and fitting the topography better. Where more than one terrace is planned, care must be taken to ensure the ridges are parallel.

Suitable outlets for the collected water behind the terrace include either vertical pipe intakes outletting into tile drains, or grass waterways. Conservation tillage and contouring are necessary to maintain terrace systems.

Terraces are a big investment, but they provide a farmer with more options in planning a cropping system. Terraces must be built right and maintained. It is a good idea to get experienced help to plan a terrace system.



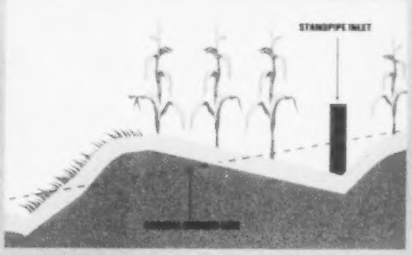
Contour strip cropping, a narrow base tile outlet terrace and no-till corn/spring grain/hay rotation can virtually eliminate erosion on this site.



Properly-designed and installed inlets make tile outlet terraces successful. They must be kept clear of debris for efficient operation.

THERE ARE THREE CHOICES TO TERRACE DESIGN: BROAD BASE, GRASS BACKSLOPE AND NARROW BASE.

BROAD BASE
The entire terrace is farmed,it is restricted to field slopes under 8%. Care must be taken not to work down the ridges during field operations. Costs are twice that of narrow base terraces.



GRASS BACKSLOPE
Suited to steeper land, the backslope is seeded to permanent vegetation.

NARROW BASE
Both front and back slopes are steep and seeded to permanent vegetation. Using bulldozers to construct, the costs should be less than $2.25/ft (1991) to complete.

RECOMMENDED TERRACE SPACING WITH AND WITHOUT A CONSERVATION MANAGEMENT SYSTEM

FIELD SLOPE (%)	WITHOUT CONSERVATION MANAGEMENT SYSTEM		WITH CONSERVATION MANAGEMENT SYSTEM	
	METRES	(FEET)	METRES	(FEET)
0 - 1	90	(300)	120	(400)
2 - 3	75	(250)	110	(350)
4 - 5	55	(180)	90	(300)
6 - 8	45	(150)	75	(250)
9 - 12	35	(120)	60	(200)

Steepness of slope, soil erodibility, crop type, management and rainfall, all determine terrace spacing. Adjustments are then allowed for matching equipment dimensions and fitting the topography better. Where more than one terrace is planned, care must be taken to ensure the ridges are parallel.

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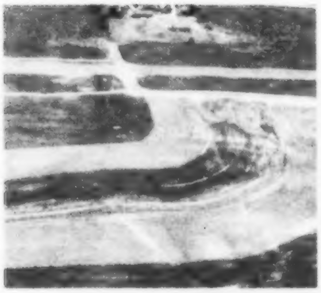

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STANDPIPE INLET
ORGINAL GROUND LINE

GRASS BACKSLOPE
Suited to steeper land, the backslope is seeded to permanent vegetation.

NARROW BASE
Both front and back slopes are steep and seeded to permanent vegetation. Using bulldozers to construct, the costs should be less than $2.25/ft (1991) to complete.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR CROPLAND

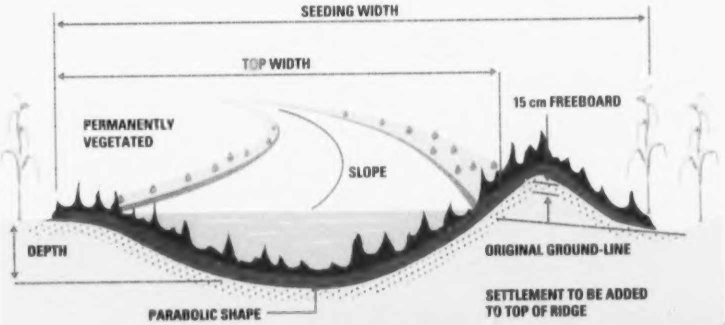
A water and sediment control basin complements other practices by controlling water erosion where surface run-off concentrates.

WATER AND SEDIMENT CONTROL BASIN

These structures are built across drainage ways and work like small dams. They intercept concentrated run-off temporarily and release it through a tile drain. Relatively inexpensive to install, these terraces will complement a conservation management system on land with irregular and non-uniform slopes.

DIVERSION TERRACE

A diversion is a channel with a supporting ridge on the lower side, constructed across the slope to intercept surface run-off, carrying it safely to an outlet. Use this system where land cannot be terraced because of topography or because it belongs to someone else. Diversions will carry substantial amounts of water and should be permanently vegetated.


SEEDING WIDTH
TOP WIDTH
15 cm FREEBOARD
PERMANENTLY VEGETATED
SLOPE
DEPTH
ORIGINAL GROUND-LINE
SETTLEMENT TO BE ADDED TO TOP OF RIDGE
PARABOLIC SHAPE

A cross-section of a diversion.

Diversions act like an eavestrough on the side of the hill to reduce slope lengths on irregular land. This system directs water to a grass waterway.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR CROPLAND

GRASS WATERWAYS

Grass waterways are broad, shallow channels protected against erosion by grass cover. They serve as outlets for terraces, diversions, contour rows or as passageways for surface flows entering the farm from other land.

Water will often collect along natural depressions in the field and run off. This is common to almost every farm. The success of a soil conservation program often requires a well-maintained grass waterway. Modern equipment will cross a grass waterway without difficulty.

Grass waterways must be wide and deep enough to handle all rains without damage. They must also be shaped to allow easy crossings by farm machinery. Crop rows should always enter the waterway at right angles.

The waterway must be well-drained to encourage vigourous grass growth and to protect the waterway from rutting when farm machinery crosses it. Tile drains can be installed along one, or both sides. A surface inlet may be installed at the upper end of the waterway to intercept long-running, overland water flow.

Occasionally, grade control is required to maintain the waterway through steep slopes. Irregular-shaped rock over a filter cloth is the most commonly used material.

A combination rock and timber control structure reduces the grade and helps control surface flow. ▲

A well-constructed and vegetated grass waterway works well with contour farming.

Generally, bulldozers are used to construct grass waterways in Ontario. Proper design ensures a good investment.

A good dense mat of grass must be established quickly. Straw mulch will help seeds germinate and offer protection against run-off until the grass grows.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR STREAMS AND DITCHES

STABILIZATION OF STREAMBANKS

All Ontario farmers must remove excess water from farmland through surface and subsurface drainage. Most land does benefit from artificially-improved drainage. Just look at the extent of private and municipal drainage in Ontario!

Ditches and streams in rural areas are too often viewed simply as drainage outlets for agricultural land.

Unfortunately, local and downstream impacts are often overlooked in drainage planning:

- ▸Fisheries and wildlife concerns must be addressed.
- ▸Flooding impacts must be considered. In many instances, maintenance or minor alterations may be all that is necessary to satisfy drainage concerns. See the booklet on Farm Forestry and Habitat Management for more information.

Streambank stabilization begins on the land near the stream. Keep erosion to a minimum with a well thought out conservation farm plan.

Cropland should be separated from the watercourse with permanent buffer strips at least three metres (10 feet) in width. Buffer strips can help filter out sediment in run-off water while stabilizing the streambanks.

Vegetation along stream corridors offers habitat for wildlife and reduces maintenance costs. Bird populations will increase, which can reduce the number of insects and pests.

A well-constructed municipal drain.

A five-year-old tree planting with shrubs, grass and brush piles offers habitat to wildlife along a drain corridor.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR STREAMS AND DITCHES

A diversion along a stream directs field run-off to a temporary ponding area. Water then is released slowly into the stream through a vertical pipe inlet leading to a tile drain.

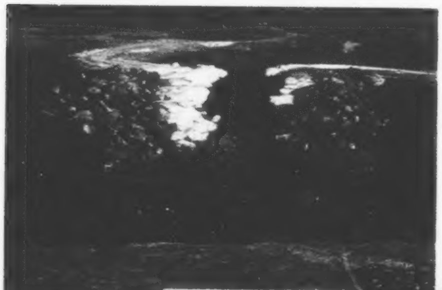
Ideally, a combination of meadow, shrubs and trees will be established along the buffer to offer diversity to wildlife. Straightening field boundaries next to meandering streams or on flood prone areas, improves management efficiency.

Bring surface run-off from nearby fields into the watercourse at as few locations as possible. Use diversions, terraces and grass waterways where necessary. Complete these projects with rock chutes or drop inlets designed to resist erosion.

All watercourses will suffer some bottom scour and bank erosion. Municipal drains, designed for the efficient removal of run-off water will erode, even if precautions have been taken to reduce erosion in vulnerable areas with rock or vegetation. During low flow periods, the channel will try to regain a meander pattern to reach a balance with nature. Allowing the stream to regain its natural shape will likely improve water flow and water quality. Then, only ongoing maintenance will be necessary.

Properly-sized, irregular-shaped rocks with a filter blanket underneath, protect the lower bank while vegetation protects the upper portion.

Run-off flows from cropland and into a drain through a rock chute. Rough field stone with filter cloth underneath is used to protect the chute. Angular stone locks together to hold everything in place.



▶ An interceptor tile drain removes seepage and strengthens the streambanks.

A log crib ▲ structure provides bank protection and fish habitat.

Fish habitat and protection devices, such as "lunker" structures, can also help stabilize banks.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR STREAMS AND DITCHES

A diversion restricts water flow to one side of this stream while a machinery crossing is installed.

Any work carried out in or around water in Ontario requires a work permit from the Ontario Ministry of Natural Resources, before starting the project... IT'S THE LAW!

It may be necessary to repair and protect certain sections of streambanks where considerable erosion occurs. Among the most commonly-used materials are rock, vegetation, log cribs or gabion baskets.

Streambanks may slump and become a problem when groundwater seeps out along the bank. Tile drains can be installed to intercept the seepage and may provide a less costly alternative to some surface protection techniques.

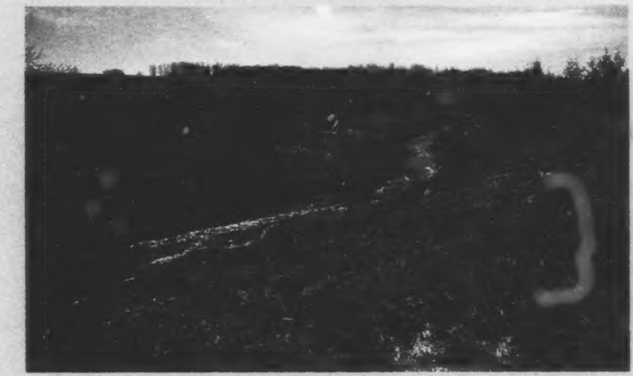
Debris, sediment and channel structure all offer good stream habitat. Too much material, however, may cause problems, up rooted trees, excessive sediment or logs spanning the channel should be removed.

Methods used to minimize damage to the stream could include:

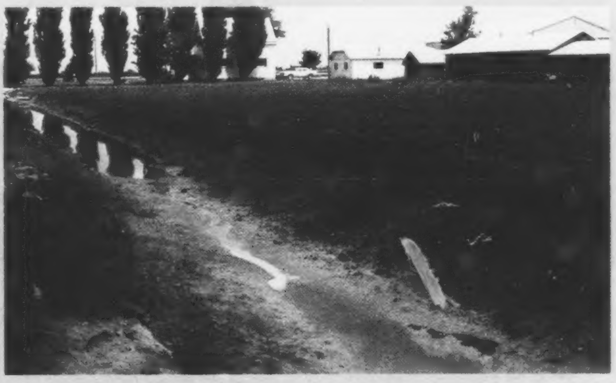
- Use the smallest equipment feasible (ie. a chainsaw and a winch to remove or reposition a log).
- Work only from one side of the channel.
- Construct sediment basins downstream from the work area.
- Do not carry out work in critical fish spawning or egg incubation periods.
- Use temporary dams or diversions during construction.

Other approvals may be required from the provincial government, agencies or the municipality. Refer to the legislation listed at the beginning of the section.

EFFECTS OF STREAM MODIFICATIONS



MINOR ALTERATIONS TO STREAMS:
- **Tends to preserve water quality.**
- **Provides less flood relief locally but does not create downstream problems.**
- **Maintains wetlands and water table.**
- **Creates diverse habitat.**



A CHANNELIZED STREAM:
- **Tends to degrade water quality.**
- **Relieves local flood problems but may increase flooding downstream.**
- **Could drain wetlands and lower water table.**
- **Provides very little habitat for wildlife or fish.**

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR STREAMS AND DITCHES

TILE DRAIN OUTLET STABILIZATION

Tile drain outlets should be installed in a manner which does not cause an obstruction or erosion in a receiving watercourse.

A properly-installed tile outlet.

LIVESTOCK FENCING AND STREAM CROSSINGS

Livestock should be restricted from all watercourses. They trample banks and destroy vegetation increasing erosion and contaminating water with manure.

Many fencing alternatives are available. Modern systems will withstand severe flood water and ice flow and cost as little as $1.64/m ($0.50/ft.) installed (1991). Watering facilities such as nose pumps, side-hill spring boxes or a solar-powered pumping system may be installed if livestock do not have access to other water sources.

An acceptable livestock crossing restricts stream access at all times. The crossing could be at bank-level such as a bridge or culvert, or a low-level crossing such as a series of culverts, or single rectangular concrete conduit. Fencing must extend over the crossing during the seasons that livestock are on pasture.

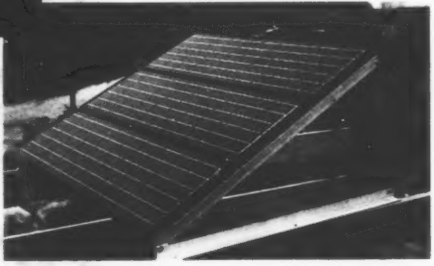
This part of the stream offers excellent fish habitat. As little as eight years ago, livestock had direct access to the stream and had removed all grass cover.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR STREAMS AND DITCHES

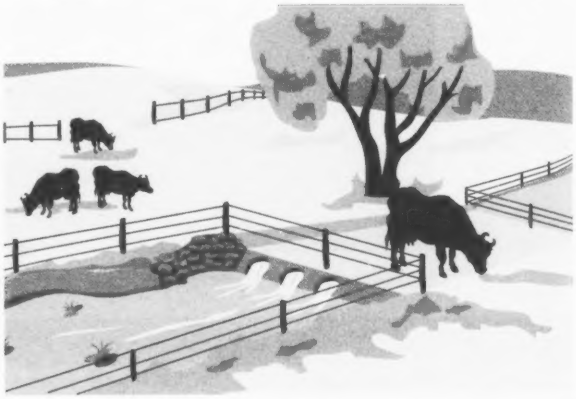
In addition to designs suitable as crossings for livestock, machinery crossings may also include low-level crossings. Concrete, stone or other man-made products such as the plastic confinement system shown are options.

▲ High tensile fences bend when subjected to ice and debris flow, but snap back to their original position afterwards.

Solar panels can be used to charge batteries to power a water pump and high tensile electric fence to restrict livestock from the creek. ▼



This low-flow crossing gives livestock access to pasture on both sides of the creek. Culverts allow normal stream flow to move beneath, while major flows can pass over the crossing without damaging it. ▼



The plastic confinement system looks like a honey comb. When filled with gravel, it makes a relatively inexpensive machinery crossing.

Weeds and grass should be kept away from an electric fence so that it is not shorted out. Herbicides may be carefully applied in the fall to control grass.

▲ A single culvert combined with permanent fencing keep livestock from a watercourse. The channel narrowed itself which provides better fish habitat.

NON-TILLAGE OPTIONS – CONSERVATION STRUCTURES FOR STREAMS AND DITCHES

[illegible]

As discussed in the introduction, farmland is best used within its capability. In many instances, land is not suited to intense agricultural production. These lands, generally classified as marginal or fragile land, should be retired to pasture, grasslands or woods.

Marginal land includes relatively level land which is not subject to severe erosion but due to poor drainage, stoniness or shallow soils, is not suited for cultivation.

Fragile lands could include areas alongside creeks, lakes and wetlands that may be subject to severe erosion or flooding. Fragile areas may also include land which is too steep for regular cultivation, for example slopes in excess of 15%. These areas are prone to severe water and wind erosion or damage from tillage and are best suited to pasture, hay or woods.

Few options exist for these lands. Farmers must decide if production from these areas makes economic sense. Increased use of fertilizers, new crop varieties and management may sustain crop yields in the short-term but as soils become less productive because of erosion, profitable farming will also suffer. Refer to the booklet on Farm Forestry and Habitat Management for alternatives on these lands.

This 15% slope has been taken out of crop production and planted with white pine. ▲

Cropping land immediately next to a swamp or wetland is most often not profitable.

Include trees, shrubs and grass to offer diverse habitat to wildlife. Each should be considered when retiring land.

Fragile land can be too steep for safe farming and is sensitive when cultivated.

TROUBLE SHOOTING

PROBLEM DESCRIPTION	SITUATION	SOLUTIONS
Excessive sheet erosion on a hillside, 180 metres (600 feet) long with 4% slope. Due to soil types and livestock base, conservation tillage is not a preferred option at this time. Would like to try strip cropping but forages are not grown. Rotation includes corn, winter wheat and barley planted across the slope.	Although cropped across the slope, the field exceeds the slope length limit of 90 m (300 ft.) Run-off will be experienced regularly with noticeable soil movement.	Strip crop with 50% - winter wheat or barley and 50% - corn on critical slope. Try mulch-till on small acreage as a trial.
Natural drainage way through farm receives run-off from neighbours' land before entering property. Low area is in grass but rills developing along edges and appears higher in middle.	Excessive soil erosion upslope and on fields alongside caused build-up of sediment in the waterway.	Prepare and construct grass waterway to meet the requirements of the input area, soil type and slopes. Keep it large enough to handle at least the peak run-off expected during a one in ten year storm. Never cultivate or plant parallel to the waterway. Control erosion on land coming into the waterway (at least from your own fields) with conservation management to reduce soil movement.
Practising no-till across the slope, but still experiencing rilling through natural drainage ways.	No matter what the tillage or conservation management system, at some time run-off will occur, and if not protected, erosion will result.	Options which may reduce erosion include: improved tile drainage, grass waterways, or terracing (water and sediment control basin).
Bank slumping along a natural watercourse on the property. I have an old foundation at my disposal, can I lay it on the bank to fix the problem?	Cause may be excessive stream velocities, or overland flow from upland, or bank seepage.	Determine nature of problem. Contact necessary approval agency as legislation applies on all work done on any stream or municipal drain. They may suggest alternatives or forward you to appropriate specialists. You may even come up with an approved solution on your own. This will depend somewhat on the magnitude of the problem and the sensitivity of the stream.
In one corner of an 'L' shaped field the land falls off abruptly. Rills are forming down the rows where it is cropped up and down the slope. This land is regularly no-tilled to either corn, soybeans or wheat.	Water will always tend to concentrate and flow down the rows. Rilling will be common.	Why not try staying on the contour by turning the corner of the 'L'. A triangular piece of land will be left out (most likely less area than you think) and could be planted to grass or trees. This will improve farmability at very little expense.
Have established contour buffer strips across a sensitive slope on the farm. Yet still noticing that the area immediately upslope is wet for extended durations in the spring and after rain.	The buffer strips are designed to intercept run-off water and sediment from above. Eroded soil which is trapped in the buffer is affecting the natural drainage of the area.	May need to improve drainage with tile system. Delay spring field work in this area if possible. Also, vegetation in buffer should be able to withstand wet soil conditions.

TROUBLE SHOOTING CONTINUED

PROBLEM DESCRIPTION	SITUATION	SOLUTIONS
A high percentage of the seedlings planted as a windbreak are dying.	Possible causes of low survival are poor stock, poor site preparation, weed competition, lack of moisture, or rodent damage.	Handle stock with considerable care. Prepare site the year before by eliminating troublesome weeds and establishing grass. Following planting, keep weed pressures down with chemical sprays, tillage, or manual clipping. Control rodents with bait or tree wraps. Water if possible during droughts.
Weed pressures are high and appear to be out-competing new tree seedlings.	Possible causes are poor site preparation or inadequate grass and weed control at time of planting.	Mechanically control weeds with mulches such as wood, paper or plastic. Clip grass and weeds as necessary. Chemically control weeds and grasses with recommended herbicides. Control competition for 3 to 5 years to ensure maximum growth and survival.
I want to plant a windbreak on my own. How do I determine the number of trees I need?	Any landowner can purchase trees and plant them. Information on site preparation, planting and maintenance is readily available if you know where to look.	Good information is available from MNR, OMAF or your local Conservation Authority. Tree spacing depends on species selected. Norway spruce and white spruce should be planted at 2 m (7 ft.) spacing. White cedar and wildlife shrubs are placed 1.5 m (5 ft.) apart. Hardwood trees at a 3 m (10 ft.) spacing. Multi-row windbreaks should maintain at least 2 m (7 ft.) spacing between rows. Adjust for maintenance equipment used for cultivating or spraying.
I have tried removing my livestock from the river that flows through my pasture with permanent fencing. But every year the fence is damaged during the winter/spring.	High floodwater and ice can easily destroy some permanent fence systems.	High tensile electric fencing is an alternative. It is designed to withstand ice flows. With electric fence, position the lowest wire high enough to avoid shortage from vegetation. Clip or chemically spray vegetation. If fencing such as page wire is preferred it must be located out of the floodplain, away from potentially damaging ice.
I work my fields across the slope and do not see any visible erosion except on my headlands. The field slope is only about 2% grade and only 120 metres (400 feet) long.	Working across the slope does not mean on the true contour. Run-off water will follow the crop rows when working across the general slope. When the run-off reaches the headland, it will turn downslope, and collect, whether there was a dead furrow or not.	Any slope over 2% should have grass field borders. If this is not acceptable, turn the rows upslope slightly at the ends to follow the contour and direct water into the field. However, you may just be moving the problem somewhere else in the field.

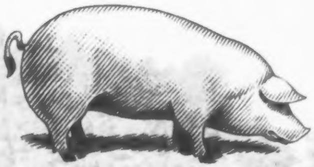
CASE STUDY

The following case study is an actual conservation farm plan initiated, and in the midst of being carried out, by a landowner in Zorra Township, Oxford County.

Initial contact was made by the landowner to local conservation staff in early 1990.

Type of operation:

- Swine (farrow to finish).



Land Base

- 200 acre parcel.
- 183 acres tillable (11 ac. woodland, 6 ac. buildings, lanes and horse paddock).

Soils

- Clay loam texture.

Drainage

- Good natural drainage.

Cropping and Tillage System

- Rotation of corn/corn/small grain underseeded to red clover.
- Fall moldboard plowing of less erosive areas, spring plowing of steeper land.
- Manure applied to red clover ground and corn stubble in the fall, and corn stubble in the spring.

Topography

- Rolling topography with relatively simple slopes.
- Variable 3 to 8% slope steepness and 600 to 1050 ft. slope lengths.
- The farm lies within 350 feet of a lake.

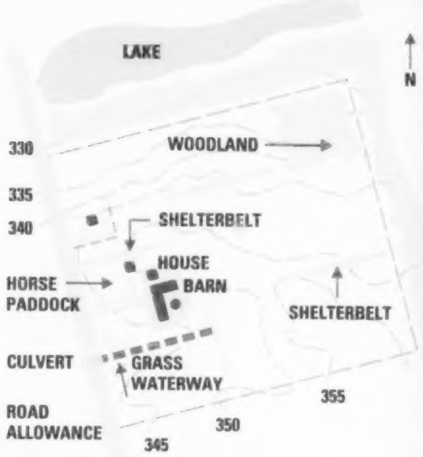
Field Equipment

- Tractor (100 Hp with front assist).
- Corn planter, 6 row (@ 30 inch).
- Sprayer(s), custom done with 60 ft. boom width.

[illegible]

Conservation practices in-place:

- ▶All field operations carried out across the slope.
- ▶Rotation.
- ▶Red clover plowdown.
- ▶Windbreaks around buildings.
- ▶Spring primary tillage.
- ▶Grass waterway to protect drainage way in southwest section of farm.


LAKE
N
330
WOODLAND
335
340
SHELTERBELT
HOUSE
HORSE PADDOCK
BARN
SHELTERBELT
CULVERT
GRASS WATERWAY
355
ROAD ALLOWANCE
350
345

Sketch of farm with five-metre contour intervals shown.

[illegible]

Landowner is aware of on-farm and off-farm impacts resulting from excessive soil erosion.

On-farm

- ▶Rills visible on hillsides of three fields and minor sedimentation at bottom of slopes.
- ▶Two irregularly shaped fields of less than one acre lying on extreme slopes are difficult to manage.

Off-farm

- ▶Directly impacts lake north of property.

[illegible]

Generally, a field-by-field analysis is suggested to assess erosion related concerns. In this instance, the farm is divided into three fields which are relatively consistent in steepness and length. Therefore, the approach chosen for conservation management will be the same for each field.

EVALUATION OF EXISTING SITUATION

Rill erosion is a visible concern on most of the sloping land following 'large' rainfalls.

A general investigation shows that although erosion has taken place (it may have been occurring beyond tolerable limits), the productive capacity of the land is still good. Under a good conservation management system, long term productivity will be sustained and possibly increased.

The existing crop rotation will continue as corn/corn/small grain (underseeded to red clover). Assume tillage practices will remain as they are now, but the landowner is open to alternatives. Other management practices such as fertility, pest, manure, etc. will remain as they are now.

PERFORMANCE GOALS

An erosion limit of less than 3 tons/acre/year on all cropland is desired by the landowner.

IMPROVEMENTS

A conservation plan for all of the cropland is preferred at this time.

Conservation tillage, cropping and structures, and land retirement may be alternatives that would fit into management plans.

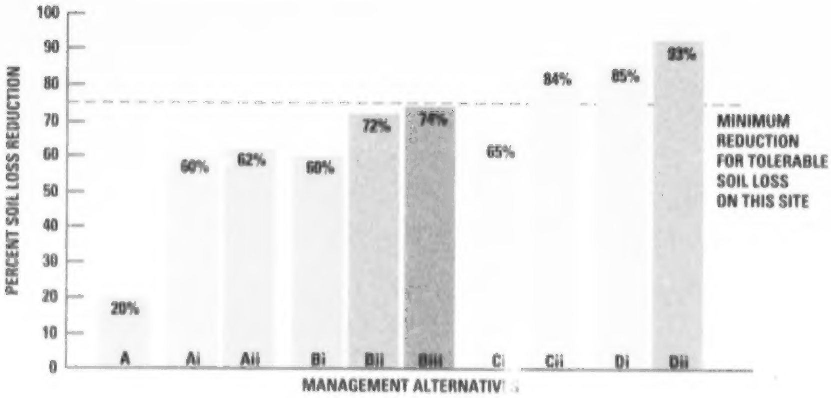
Assume in planning that farm equipment would remain as is, but the landowner would like to try mulch-till on ground in place of the moldboard plow and no-till with small grains. Manure would then only be applied on land to be mulch-tilled.

ALTERNATIVES AVAILABLE AND SELECTION

Using the Universal Soil Loss Equation, a number of conservation management systems were evaluated.

Based on existing management, a 75% reduction in soil loss would be necessary to maintain a tolerable level of 3 tons/acre/year soil loss. Existing management, for the purpose of the evaluation of alternatives, includes fall moldboard plowing all land across the slope and a corn/corn/small grain with red clover underseed rotation.

The following chart illustrates the best management practices considered in the planning process, and their relative effectiveness in reducing soil erosion by water.

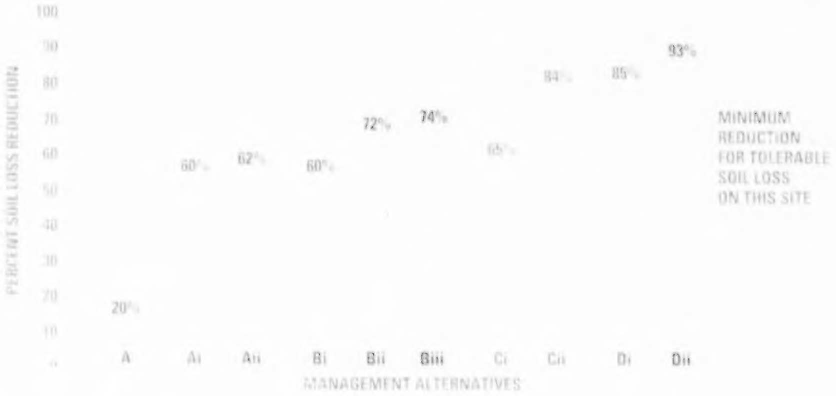


The chart illustrates the best management practices considered in the planning process and their effectiveness in reducing soil erosion by water.

RELATIVE EFFECTIVENESS OF BEST MANAGEMENT PRACTICES CONSIDERED

CHART LEGEND	MANAGEMENT ALTERNATIVES	RELATIVE PERCENT REDUCTION IN SOIL LOSS
	TILLAGE OPTIONS	
A	Spring moldboard plow all ground	20
Ai	Mulch till all ground	60
Aii	Mulch till corn, no-till small grain	62
	Strip Cropping Corn and Small Grain at 120 ft. Wide Strips.	
Bi	Fall moldboard plow all ground	60
Bii	Mulch till all ground	72
Biii	Mulch till corn, no-till small grain	74
	Terracing at 300 ft. Spacing.	
Ci	Fall moldboard plow all ground	65
Cii	Mulch till all ground	84
	Strip Cropping Corn and Small Grain at 120 ft. Wide Strips and Terracing at 360 ft. Spacing.	
Di	Fall moldboard plow all ground	85
Dii	Mulch till all ground	93

The recommendations for the two, irregularly-shaped fields experiencing erosion, were to establish forage which could be used for feed for horses (hobby), or, simply retire the land and plant to trees.



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The recommendations for the two, irregularly-shaped fields experiencing erosion, were to establish forage which could be used for feed for horses (hobby), or, simply retire the land and plant it to trees.

EVALUATION AND IMPLEMENTATION

A conservation farm plan was initiated in 1990, when the landowner contacted local conservation staff. Necessary site visits and surveys were conducted in the summer of 1990. Over the winter, plans were drawn up based on the alternatives outlined previously. Implementation was proposed to extend over a few years.

Terracing

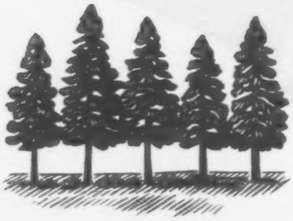
Four terraces, three narrow based tile outlet and one diversion were constructed in 1991. In order to facilitate the construction in August (the best possible time for work of this nature), spring grain was grown at proposed terrace locations.

The terraces will serve to limit maximum slope length on any field at 360 feet. This spacing falls within the suggested guidelines for terraces as shown on page 117 and also blends in with a proposed strip cropping layout.

Investigations were made into the state of the existing tile drainage system. If possible, in order to save money, the existing tile drains would be incorporated into the terrace designs. The original tile installer was contacted, and fortunately site maps showing tile drain layout and sizes, were available. It was determined that the tile system was recently installed and that it would easily handle the terrace design requirements. Water will not pond longer than 24 hours on the cropland.

Two terracing patterns were considered; an east-west, across the slope system, and a true contour system. The soil loss reductions would be relatively the same with either system. Based on management preference, the pattern offering parallel field boundaries was selected.

In 1991, over 4,000 feet of terraces were constructed using bulldozers, by the original tile drain installer, at a cost of less than $2.00/ft. complete. This was cost-shared through the Land Stewardship II Program.



Strip Cropping

With the terraces at a 360 ft. spacing, it is proposed that three 120 ft. strips of alternating small grain and corn should complement the system. A rough strip cropping pattern was started in 1990, when strips of corn and small grain were grown to allow for terrace construction. The entire farm will not be strip cropped each year, but rather, the system will be rotated through the cropland as management determines necessary.

Tillage

A mulch-tiller was purchased by the landowner in 1991 and will be used in place of the moldboard plow as management allows. Land Stewardship II assisted in cost-sharing this implement.

Trials will begin with a no-till drill in 1992. Either spring or fall cereals will be planted on a small acreage to determine the system's capability on the farm. Ideally, if the reduced tillage practices are successful, strip cropping would be used only in the most erosive fields.

Trees

The landowner has established shelterbelts around the farm buildings. Windbreaks and hardwood plantings are planned along terrace boundaries.These areas may be used as walking and horse trails.

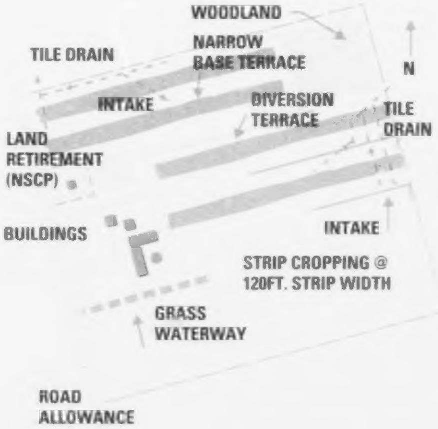
Fragile Land Retirement

Approximately one acre of highly erodible land was taken out of production and planted to trees, under a National Soil Conservation Program agreement. The flat top land adjacent to the fragile land will be used for forage production.

The farmstead shelter belt was enhanced by additional plantings and management was eased by squaring off the field in this area.

In fact, top soil may be generated on the farm with good nutrient, manure, and rotation / cover crop management. The terraces will serve to maintain slope length limits. Cropping and tillage management will continue to be fine-tuned. The conservation planning process is never ending, the landowner can continually strive to improve his system to fit his objectives.

Overall, it is anticipated that erosion levels will average less than 1 ton/acre/year.


WOODLAND
TILE DRAIN
NARROW BASE TERRACE
N
INTAKE
DIVERSION TERRACE
TILE DRAIN
LAND RETIREMENT (NSCP)
BUILDINGS
INTAKE
STRIP CROPPING @ 120FT. STRIP WIDTH
GRASS WATERWAY
ROAD ALLOWANCE

Best management practices implementation (conservation farm plan).

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Conservation Authorities - Extension Services Personnel.

Certified Soil Erosion Control Contractors.

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